

FOR THE
IB DIPLOMA
PROGRAMME

THIRD EDITION

Biology

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Practice Exam-style Questions



 **HODDER**
EDUCATION
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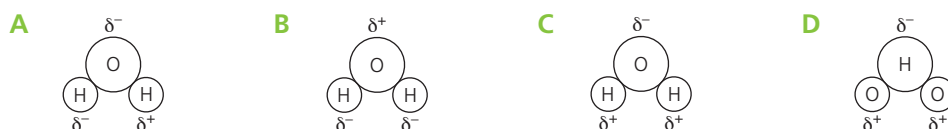
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A1.1 Water

Paper 1

1 Which diagram correctly indicates the polarity in a water molecule?



Higher Level Paper 1, Time Zone 1, May 09, Q8

2 With regards to water molecules, where do hydrogen bonds form?

- A** Within a water molecule, between the negatively charged hydrogen atom and positively charged oxygen atom
- B** Between different water molecules, between the negatively charged hydrogen atom and positively charged oxygen atom
- C** Within a water molecule, between the positively charged hydrogen atom and negatively charged oxygen atom
- D** Between different water molecules, between the positively charged hydrogen atom and negatively charged oxygen atom

3 Four properties of water are listed below. Which of the properties explain why water makes a good solvent?

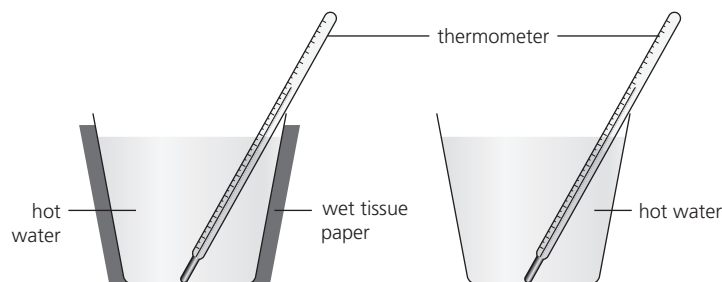
- I** The polarity of water molecules
- II** The high specific heat capacity of water
- III** Hydrogen bonds
- IV** Water is less dense as a solid than as a liquid

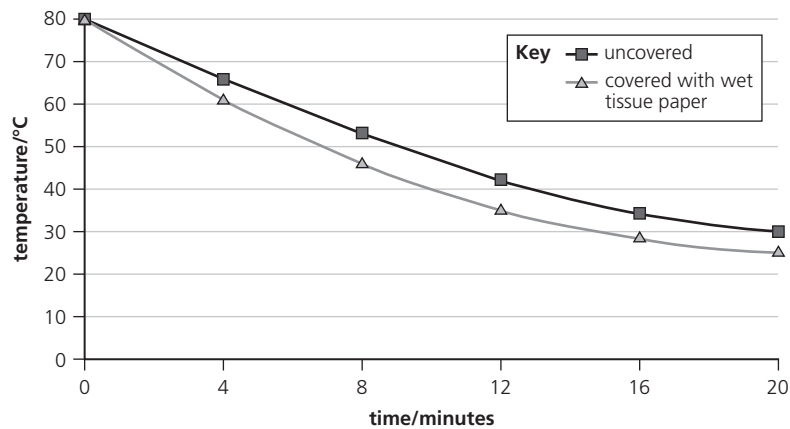
- A** I and II only
- B** I and III only
- C** III and IV only
- D** I, II and IV

4 Which is the correct explanation of cohesion?

- A** The property of the surface of a liquid that allows it to resist an external force
- B** The force by which individual molecules of the same type are attracted
- C** The force by which individual molecules link to surrounding surfaces
- D** The force by which individual molecules of different types are attracted

5 To investigate the thermal properties of water, students placed hot water in two thin plastic cups and measured their rate of cooling. The sides of one cup were covered with tissue paper soaked in hot water; the other cup was left uncovered. The temperature was recorded with a thermometer every 4 minutes for 20 minutes. The temperature in the laboratory was 18 °C.





- a Calculate the change in temperature in each cup after 20 minutes:
 - i uncovered [1]
 - ii covered with wet tissue paper. [1]
- b State **two** conditions that must be the same for each cup at the start of the experiment. [2]
- c Predict the temperature of the water in the cups after 3 hours. [1]

Standard Level Paper 3, Time Zone 0, November 17, Q1a–c

(Questions 6–8 HL only)

- 6 The abundance of water over billions of years of Earth's history has allowed life to evolve. Which of the following is an explanation for the origin of water on Earth?
 - A It has always been found on the surface
 - B Volcanic activity
 - C It was formed by respiration when life evolved
 - D It was brought to Earth on asteroids
- 7 Why was water retained on the early Earth?
 - A Temperatures were low enough to condense water
 - B Seas were able to form
 - C The ozone layer prevented water from evaporating
 - D The water cycle had been established
- 8 What is a correct definition for 'Goldilocks zone'?
 - A Zone in a planetary system where gold is found
 - B Specific distance from a star where the gravitational pull is not too great or too small
 - C Specific distance from a star where the temperature is suitable for liquid water and therefore life
 - D Area of a planet where water is found

Paper 2

- 1 With the use of a diagram, outline how hydrogen bonds form in water. [3]
- 2 a Draw three water molecules and show how bonds can form between water molecules. [2]
b Annotate your diagram with the name of the bond. [1]
c Indicate the polarity in each water molecule. [1]
- 3 Water has important solvent properties. Explain these properties using examples to illustrate your answer. [3]
Standard Level Paper 2, Time Zone 0, November 17, Q3b
- 4 Identify the properties of water molecules that permit them to move upwards in plants. [2]
- 5 Describe the importance of water to living organisms. [5]
Higher Level Paper 2, Time Zone 0, November 15, Q7c
- 6 Explain the relationship between the properties of water and its uses in living organisms as a coolant, a medium for metabolic reactions and a transport medium. [8]

(Question 7 HL only)

- 7 The Goldilocks zone is the area around a star where the temperature allows water to exist in liquid form. The closest and furthest distances from the star where liquid water can be found depend, partly, on the size and temperature of the star. Water is believed to be essential for the evolution of cellular organisms.

Kepler-186 is a dwarf star in the constellation of Cygnus. It has a mass of 0.37 suns and its **luminosity** is 0.01 suns. It is known to have five planets (see the table below). The smallest one, B, is only 8% larger than Earth, while the largest one, D, is almost 40% larger.

Planet	Distance/AU	Orbit/days
B	0.04	3.88
C	0.06	7.26
D	0.09	13.34
E	0.12	22.40
F	0.40	129.94

An astronomical unit (AU) is the mean distance of the Earth from the Sun; this distance varies as the Earth orbits the Sun in an ellipse.

Luminosity is a measure of brightness or power of a star, the amount of energy that a star emits from its surface in one second. It is usually expressed in watts and measured in terms of the luminosity of the Sun.

- a Calculate the distance in AU of the Goldilocks zone for Kepler-186 using the formula $\sqrt{\text{luminosity of the star} \times 0.7}$ for the inner edge of the habitable zone and $\sqrt{\text{luminosity} \times 1.5}$ for the outer edge of the zone. [1]
- b Deduce which, if any, of the five planets orbiting Kepler-186 are in the Goldilocks zone. [1]
- c State **one** other factor which determines whether a planet is in the Goldilocks zone. [1]
- d Outline the physical properties of water which result from hydrogen bonding between water molecules. [3]

A1.2 Nucleic acids

Paper 1

- 1 What is common to both RNA and DNA?
- A Thymine
 - B Nitrogenous bases
 - C Double helix
 - D Deoxyribose
- 2 Which statements are characteristics of alleles?
- I Alleles differ significantly in number of base pairs
 - II Alleles are specific forms of a gene
 - III New alleles are formed by mutation
- A I and II only
 - B I and III only
 - C II and III only
 - D I, II and III
- Higher Level Paper 1, Time Zone 0, November 19, Q10*
- 3 Nucleic acids are polymers of nucleotides. What parts of nucleotides are joined together in both DNA and RNA to make these polymers?
- A Large nitrogenous bases with small nitrogenous bases
 - B Nitrogenous bases with hexose sugars
 - C Nitrogenous bases with phosphates
 - D Pentose sugars with phosphates
- Standard Level Paper 1, Time Zone 1, May 18, Q11*
- 4 What is the same in all parts of homologous chromosomes?
- A Base pair sequence
 - B Sequence of genes
 - C Alleles
 - D Insertions
- Standard Level Paper 1, Time Zone 1, May 18, Q14*

- 5 How is an allele different from a gene?
- A An allele is made of RNA
 - B An allele is longer
 - C An allele is a variety of a gene
 - D An allele cannot be affected by mutation
- 6 Which statement is a similarity between DNA and RNA?
- A Both contain ribose sugar
 - B Both are polymers of nucleotides
 - C Both are only found in the nucleus
 - D Both contain adenine, cytosine and thymine
- 7 What usually distinguishes DNA from RNA?

	DNA	RNA
A	strands are symmetrical	strands are antiparallel
B	contains adenine	contains cytosine
C	pentoses linked to phosphates	pentoses linked to bases
D	double stranded	single stranded

Higher Level Paper 1, Time Zone 0, May 16, Q5

(Questions 8–10 HL only)

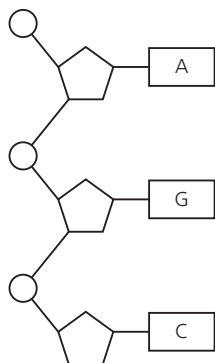
- 8 Which of the following conclusions are supported by evidence from the Hershey–Chase experiment?
- A DNA is the genetic material
 - B Protein is the genetic material
 - C Bacteriophages contain DNA
 - D Cells contain DNA
- 9 What did Erwin Chargaff discover?
- A The number of adenine bases equalled the number of thymine bases
 - B The number of bases varies between different organisms
 - C Uracil is found in RNA
 - D DNA is the genetic material in cells
- 10 What is the role of histones?
- A Construction of the cytoskeleton in cells
 - B Packaging of DNA in chromosomes
 - C Giving stability to plasma membranes
 - D Enzymic activity in cells

Paper 2

- 1 Draw a labelled diagram of a section of DNA showing four nucleotides. [5]

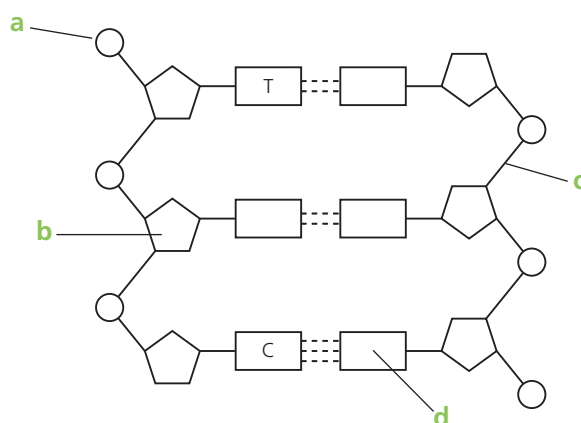
Standard Level Paper 2, Time Zone 0, November 15, Q5a

- 2 Sketch the complementary strand to complete the section of a DNA diagram with the correct complementary bases. [3]



- 3 List two structural features that are the same between RNA and DNA. [2]

- 4 The diagram shows a section of a DNA molecule. State what is indicated by the labels a, b, c and d. [2]



- 5 Hydrogen bonds can exist both within and between molecules in living organisms and have an impact on their structure and function. Explain the importance of hydrogen bonding for living organisms. [7]

Higher Level Paper 2, Time Zone 1, May 18, Q6c

(Questions 6 and 7 HL only)

- 6 Deduce the significance of the positively charged histone protein and the negatively charged DNA. [3]
- 7 Explain how scientific evidence was used to describe the structure and function of DNA. [8]

A2.1 Origins of cells (HL only)

Paper 1 (HL only)

1 The atmosphere on the early Earth included:

- A Ammonia
- B Oxygen
- C Ozone
- D Carbon monoxide

2 Where did the Last Universal Common Ancestor (LUCA) probably evolve?

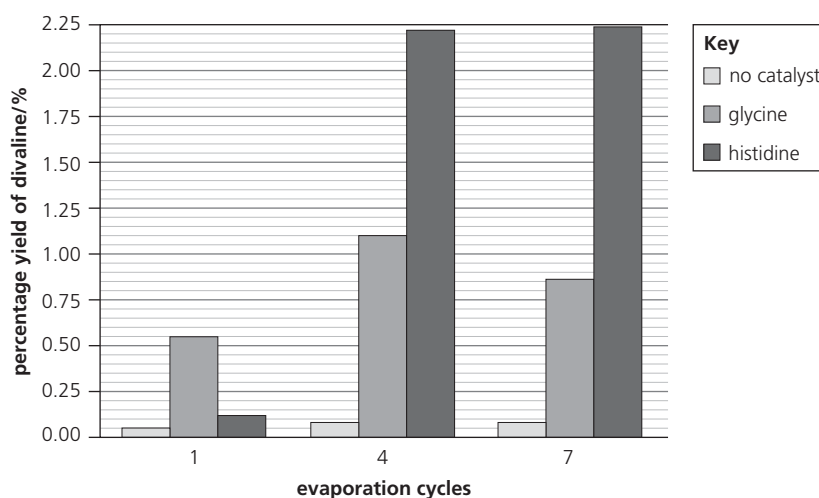
- A Salt marshes
- B Deep sea hydrothermal vents
- C Peat swamp
- D Extinct volcanoes

3 Which of the following features suggest that RNA had a central role in the origin of life?

- I RNA is a carrier of genetic information
- II RNA can act as a catalyst
- III RNA contains the base uracil not thymine

- A I only
- B I and II
- C I, II and III
- D None of those listed

4 The synthesis of complex organic molecules in sea water is believed to be an important step in the evolution of life on Earth. Researchers investigated whether the evaporation of sea water containing amino acids could catalyse the formation of dipeptides such as divaline (valine–valine) under pre-biotic Earth conditions. They placed different amino acid combinations in a chamber to simulate the evaporation cycles between high tides in shallow seas. In one investigation the amino acid valine was used as the substrate and the percentage yield of divaline was measured after different numbers of evaporation cycles. The experiment was repeated without a catalyst and with either glycine or histidine as catalysts.



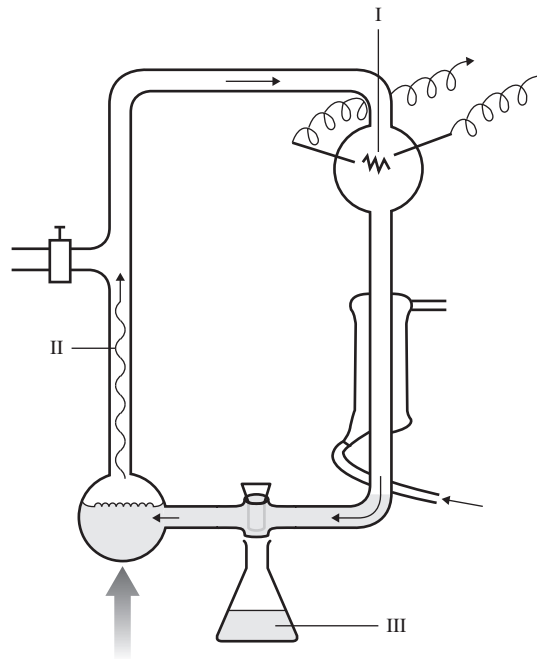
- a Compare the effectiveness of the two amino acid catalysts used in this experiment. [3]
- b This investigation was performed in a chamber at 85 °C leading to total evaporation of the salt water within one day. The atmosphere inside the chamber consisted of nitrogen, carbon dioxide and water vapour. Evaluate the experiment on the basis of similarity with conditions that existed on pre-biotic Earth. [3]
- c Outline other possible locations where conditions could have allowed the synthesis of organic molecules under pre-biotic conditions. [2]

Higher Level Paper 3, Time Zone 1, May 13, Option D Q1

■ Paper 2 (HL only)

- 1 a State the name for primitive, phospholipid-enclosed structures that may have preceded cells. [1]
 b State **two** conditions of pre-biotic Earth. [1]
 c Identify **two** properties of RNA which may have contributed to the origin of life. [2]

2



- a i The apparatus above was used in the Miller–Urey experiment. State what condition of pre-biotic Earth is simulated by I. [1]
 ii State **two** substances used in II to simulate the early atmosphere of the Earth. [1]
 iii Identify a compound (not RNA) isolated in III by Miller–Urey in this experiment. [1]
 b State **two** roles of RNA in pre-biotic Earth. [1]

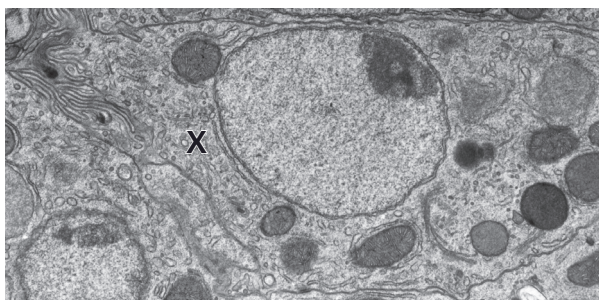
Higher Level Paper 3, Time Zone 0, November 05, Option D Q2

- 3 Evaluate the Miller–Urey experiment. [4]

A2.2 Cell structure

Paper 1

- Which is **not** an idea contained within cell theory?
 - Cells can only arise from pre-existing cells
 - All cells contain a nucleus
 - Living organisms are composed of cells which are the smallest unit of life
 - Organisms consisting of only one cell carry out all functions of life
- A chloroplast is 6 micrometres long. If a student draws it 100 times larger than its actual size, what diameter will the drawing be in mm?
 - 0.06 mm
 - 0.6 mm
 - 6 mm
 - 60 mm
- Which of these organelles has a double membrane?
 - Nucleus
 - Lysosome
 - Endoplasmic reticulum
 - Ribosome
- Which feature of both striated muscle and aseptate fungal hyphae is different from typical cell structure?
 - They have multiple nuclei within a structural unit
 - They have a cell wall that is not made of cellulose
 - They have plasmids
 - They have an absence of cholesterol in the plasma membrane
- The magnification of the micrograph is $\times 1500$. What is the maximum diameter of the nucleus in the cell labelled X?



- 10 μm
- 10 nm
- 20 μm
- 20 nm

- A highly magnified electron micrograph of an animal cell was magnified $\times 9600$. The following features were measured. Complete a copy of the table, expressing the actual size of the features in appropriate units.

Feature	Measurement on scale bar	Actual size
diameter of the nucleus	56 mm	
length of a mitochondrion	16 mm	
width of the cell	14 cm	
diameter of a lysosome	4 mm	
pore in the nuclear envelope	3 mm	
length of the cell	25.5 cm	

[3]

(Questions 7–10 HL only)

- What evidence do mitochondria and chloroplasts provide in support of endosymbiotic theory?
 - They exist together in all eukaryote cells
 - They have 80S ribosomes similar to eukaryotes
 - They have double membranes
 - They contain the same DNA as the nucleus of the cell
- Mechanisms that are needed for the evolution of multicellular organisms include:
 - Cell adhesion
 - Communication between cells
 - Differentiation
 - I only
 - I and II only
 - I, II and III
 - None of those listed
- What is evidence for the endosymbiotic theory?
 - RNA can catalyse metabolic reactions
 - Meteorites contain organic molecules
 - Amino acids can be synthesized from inorganic compounds
 - Mitochondria possess their own DNA
- Which organelle provides evidence that eukaryotic cells originated when large prokaryotes engulfed small free-living prokaryotes?
 - Chloroplast
 - Nucleoid
 - 80S ribosome
 - Vacuole

Higher Level Paper 1, Time Zone 2, May 17, Q4

Standard Level Paper 1, Time Zone 1, May 18, Q4

Paper 2

- 1 Tuberculosis (TB) is an infectious disease caused by the bacterium *Mycobacterium tuberculosis*. Outline the structures in *M. tuberculosis* that are not present in a human cell. [3]

Standard Level Paper 2, Time Zone 2, May 21, Q6a

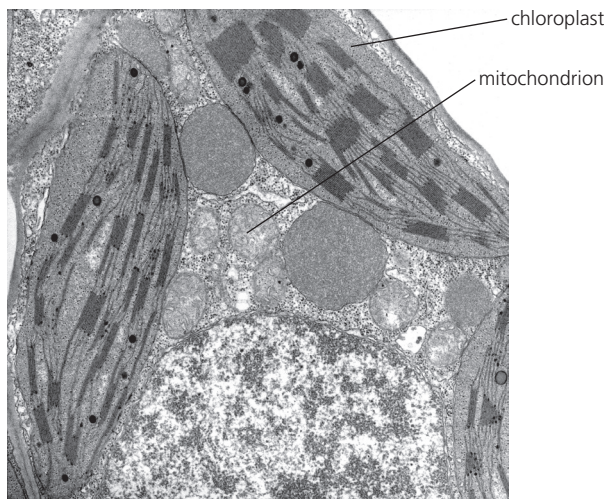
- 2 Testis cells are eukaryotic cells. Identify the structures seen under the electron microscope in testis cells that are not present in prokaryotic cells. [4]

Higher Level Paper 2, Time Zone 2, May 21, Q5c

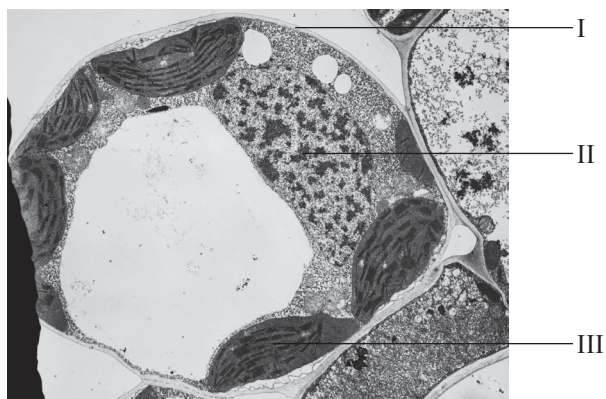
- 3 Unicellular and multicellular organisms share the same functions of life. Outline four functions of life. [4]

Standard Level Paper 2, Time Zone 1, May 18, Q5b

- 4 The micrograph shows part of a plant cell with a chloroplast near to a mitochondrion.



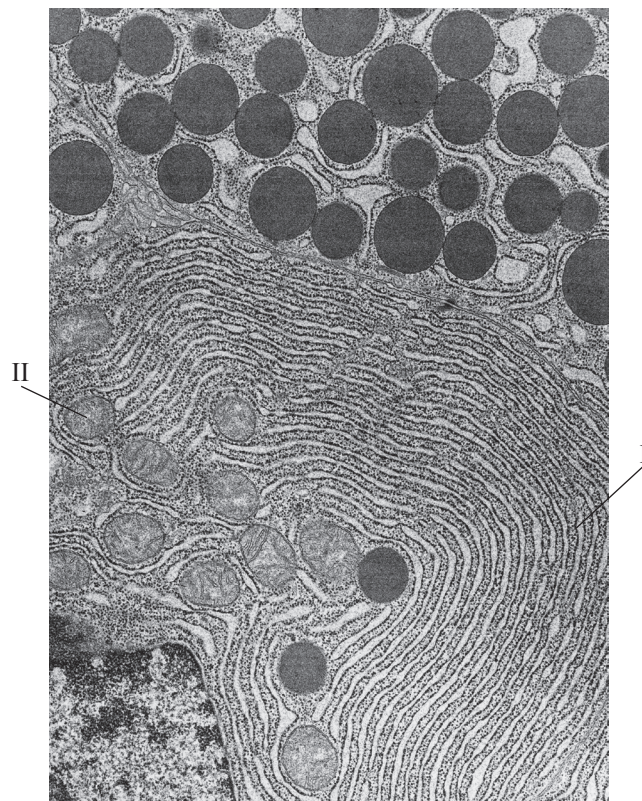
- a State **two** structural similarities between mitochondria and chloroplasts. [2]
- b Compare and contrast the functional roles of mitochondria and chloroplasts in cell metabolism. [4]
- c Suggest why the mitochondria in the micrograph appear to vary in shape. [2]
- 5 Compare and contrast the structure of the chloroplast with a typical prokaryotic cell. [4]
- 6 The electron micrograph shows a palisade mesophyll cell.



- a State the name of the structures labelled I and II. [1]
- b Outline the function of the structure labelled III. [2]

Standard Level Paper 2, Time Zone 2, May 18, Q3ai–ii

- 7 The electron micrograph shows the structures in an exocrine gland cell of the pancreas.



- a Using the table, identify the organelles labelled I and II on the electron micrograph and their principal role. [2]

Organelle	Name	Principal role
I		
II		

- b Compare and contrast the structure and functions of organelles I and II. [4]
- 8 Discuss the cell theory and its limitations. [7]

Standard Level Paper 2, Time Zone 0, November 18, Q5c

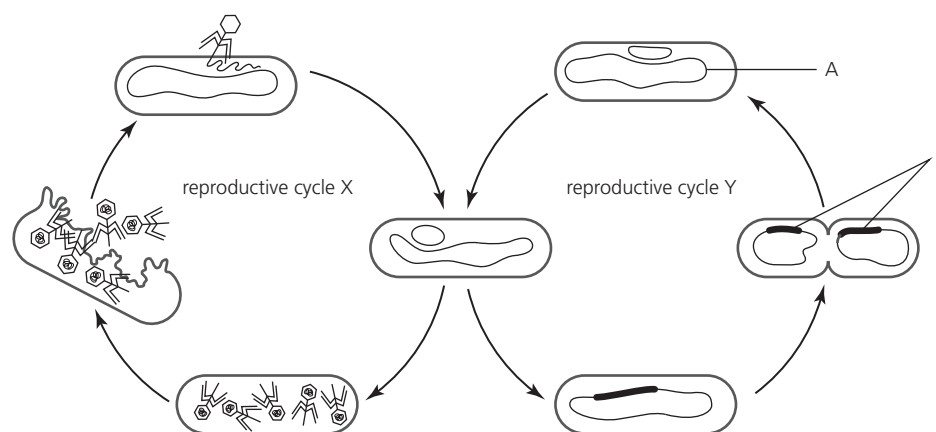
(Questions 9–11 HL only)

- 9 Apart from the ribosomes, explain the evidence for the endosymbiotic theory of the origin of eukaryotic cells. [3]
- Standard Level Paper 2, Time Zone 0, November 20, Q2d
- 10 Explain how mitochondria could have been formed from free-living prokaryotes. [2]
- Higher Level Paper 2, Time Zone 1, May 19, Q3b
- 11 Explain the reasons for differences between the proteomes of cells within a multicellular organism. [7]

A2.3 Viruses (HL only)

Paper 1 (HL only)

- Which feature of viruses result in them being considered non-living?
 - Viruses are obligate parasites
 - Viruses can only be replicated inside a living cell
 - Viruses have a protein coat (capsid)
 - Viruses contain either RNA or DNA, but never both
- Which type of enzyme allows a retrovirus to prepare its genome for insertion into a host cell's DNA?
 - DNA polymerase
 - Restriction enzymes
 - Reverse transcriptase
 - RNA polymerase
- Which of the following correctly identifies the reproductive cycles X and Y and structures A and B?



	X	Y	A	B
A	lytic	lysogenic	virus DNA	provirus
B	lysogenic	lytic	virus DNA	prophage
C	lytic	lysogenic	bacterial DNA	prophage
D	lysogenic	lytic	bacterial DNA	provirus

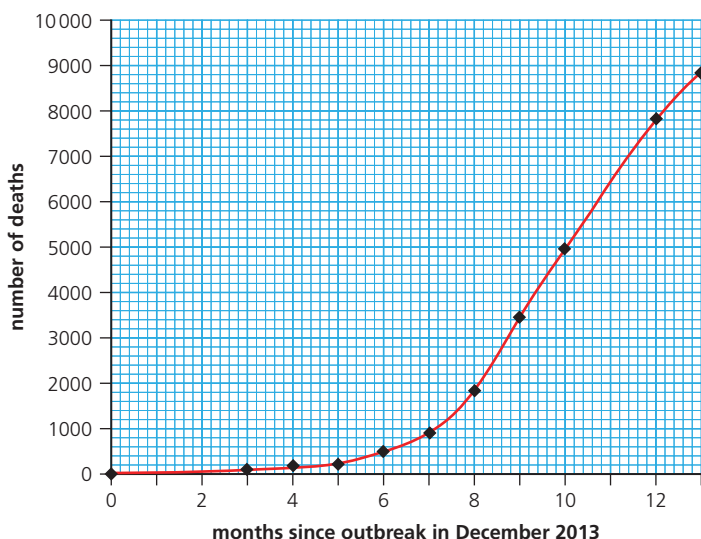
- What happens when a bacterial cell that is infected by bacteriophage lambda divides?
 - Viral RNA is replicated
 - Viral RNA is transcribed from viral DNA
 - Viral DNA is replicated
 - Viral DNA is made from viral RNA

Paper 2 (HL only)

- 1 In December 2013, a boy died of Ebola Virus Disease (EVD) in Guinea, West Africa. However, it was not until March 2014 that health officials reported a mysterious haemorrhagic fever that ‘strikes like lightning’.

By the end of 2014, an estimated 20 000 cases had been reported.

The graph shows the number of deaths reported in the months following the outbreak in December 2013.



- a Give an estimate of the percentage of reported cases who had died by the end of 2014. [1]
- b Analyse the data for July to August 2014, and December 2014 to January 2015, to explain whether the measures taken to control the spread of Ebola were effective. [2]
- c The table shows the number of reported cases and deaths from Ebola in three different countries by March 2015. Explain the difference between the percentage of reported cases who had died in these three countries. [2]

Countries with widespread transmission	Total cases (suspected, probable, confirmed)	Laboratory confirmed cases	Total deaths
Guinea	3 814	3 358	2 544
Liberia	10 678	3 163	4 810
Sierra Leone	11 829	8 706	3 956

- 2 Describe the structural components of viruses. [6]
- 3 Compare the lysogenic life cycle to the lytic life cycle. [5]
- 4 When a bacterial cell is infected with bacteriophage lambda (λ phage), the virus will enter the lytic cycle. Describe the lytic cycle of a virus. [5]
- 5 Every year, new flu vaccines are developed to ensure their efficacy. Explain the frequent need for new vaccines against influenza viruses. [2]
- 6 Some bacteriophages, such as bacteriophage lambda, undergo both lysogenic and lytic cycles. Suggest reasons why it may be advantageous for a bacteriophage to have a lysogenic cycle. [3]

A3.1 Diversity of organisms

Paper 1

1 What is a feature of the human genome?

- A Plasmids
- B Messenger RNA
- C Transfer RNA
- D Mitochondrial DNA

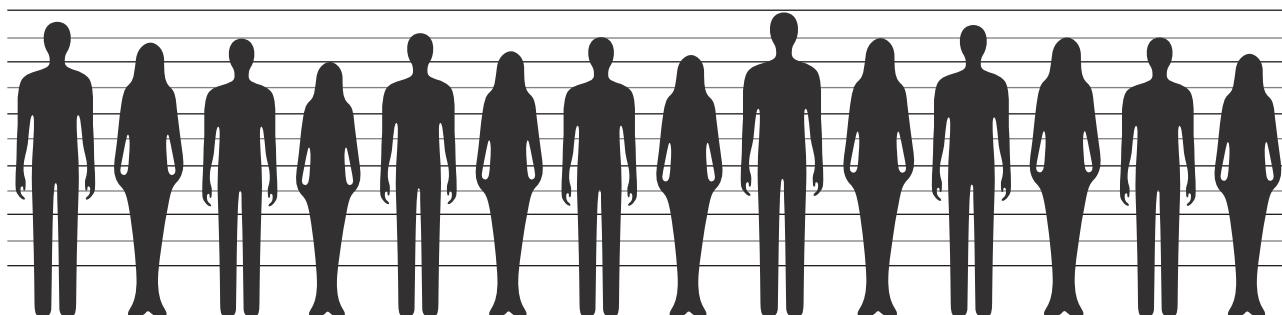
Higher Level Paper 1, Time Zone 2, May 21, Q10

2 What determines the genomic size of a species?

- A The total amount of DNA
- B The total number of genes
- C The total number of alleles
- D The total number of chromosomes

Standard Level Paper 1, Time Zone 2, May 18, Q13

3 The image shows variation in height of adult humans.



What can explain the variation?

- A One pair of alleles and age
- B Polygenic inheritance and nutrition
- C Nutrition and age
- D Autosomal inheritance only

Higher Level Paper 1, Time Zone 0, November 18, Q36

4 What is characteristic of homologous chromosomes?

- A They have an identical DNA sequence
- B They are of the same length in karyograms
- C They form pairs in prokaryotes
- D They carry the same alleles

Higher Level Paper 1, Time Zone 0, May 16, Q17

(Questions 5 and 6 HL only)

5 Difficulties of applying the biological species concept include:

- I Asexually reproducing species
- II Individuals produced by cloning
- III Bacteria that have horizontal gene transfer

- A I only
- B I and II
- C I and III
- D I, II and III

6 Cross-breeding between closely related species is unlikely to produce fertile offspring because:

- A Parent chromosome numbers are different
- B Diploid zygotes cannot be formed
- C Cell division in offspring cannot occur
- D Offspring do not have functional reproductive organs

Paper 2

1 More than 8 million different species are alive today but over the course of evolution, more than 4 billion may have existed.

- a Outline the criteria that should be used to assess whether a group of organisms is a species. [3]
- b Describe the changes that occur in gene pools during speciation. [5]

Higher Level Paper 2, Time Zone 0, November 20, Q8a–b

2 Outline the binomial system of classification. [4]

Standard Level Paper 2, Time Zone 0, November 21, Q6c

(Questions 3 and 4 HL only)

3 Explain how species can be identified from environmental DNA in a habitat using barcodes. [7]

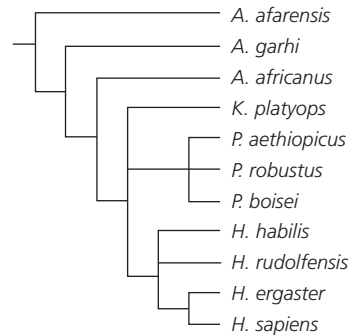
4 a Outline how dichotomous keys can be used to identify specimens. [4]

b Suggest possible limitations of using dichotomous keys to identify specimens. [2]

A3.2 Classification and cladistics (HL only)

Paper 1 (HL only)

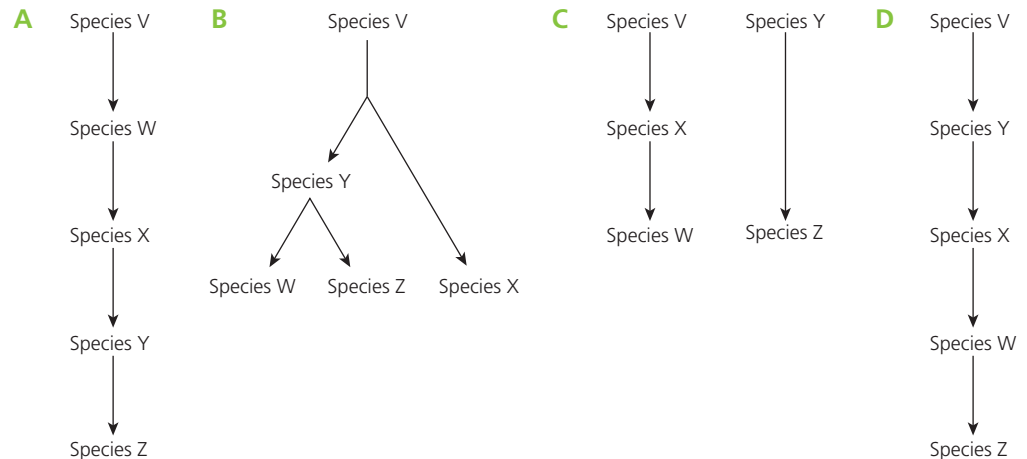
- 1 The cladogram shows one theory of how species of hominin evolved. What can be deduced using the information in the cladogram?



- A** The closest species to *K. platyops* is *A. africanus*
- B** *A. afarensis* is extinct
- C** The DNA of *H. sapiens* is the same as that of *H. ergaster*
- D** *H. sapiens* and *P. robustus* shared a common ancestor

Standard Level Paper 1, Time Zone 0, November 21, Q23

- 2 Which evolutionary pathway is most likely to result in the evolution of analogous structures in Species W and Z?

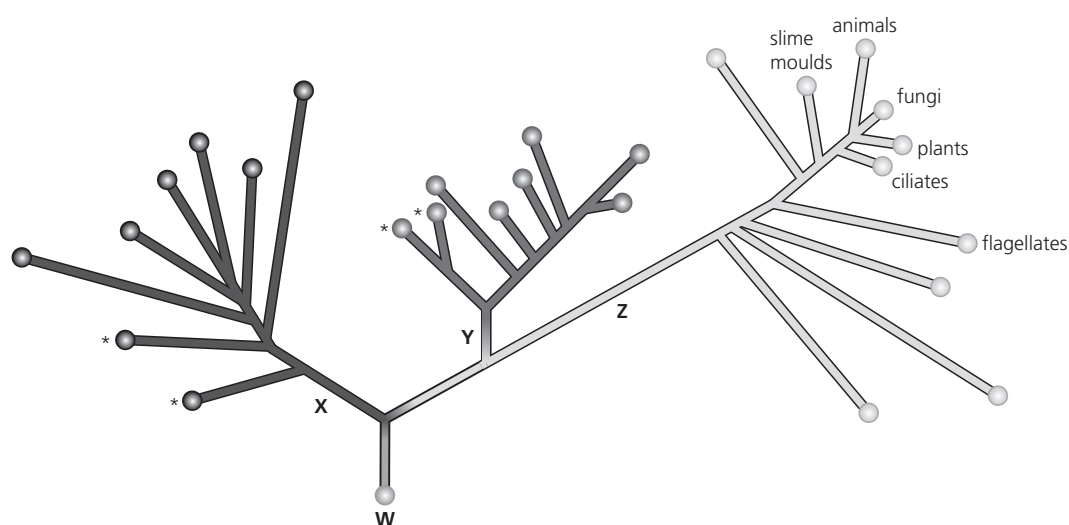


Standard Level Paper 1, Time Zone 2, May 21, Q21

- 3 What information can be deduced from the sequence of nodes in a cladogram?
- A** The geological period in which the species in the clade diverged from their common ancestor
 - B** The probable sequence of divergence among the species in the clade
 - C** The number of characteristics the species have in common
 - D** The number of mutations that have occurred since the species shared a common ancestor

Standard Level Paper 1, Time Zone 2, May 21, Q23

- 4 The diagram shows living organisms divided into the three domains. Select the row in the table that correctly identifies W, X, Y and Z.



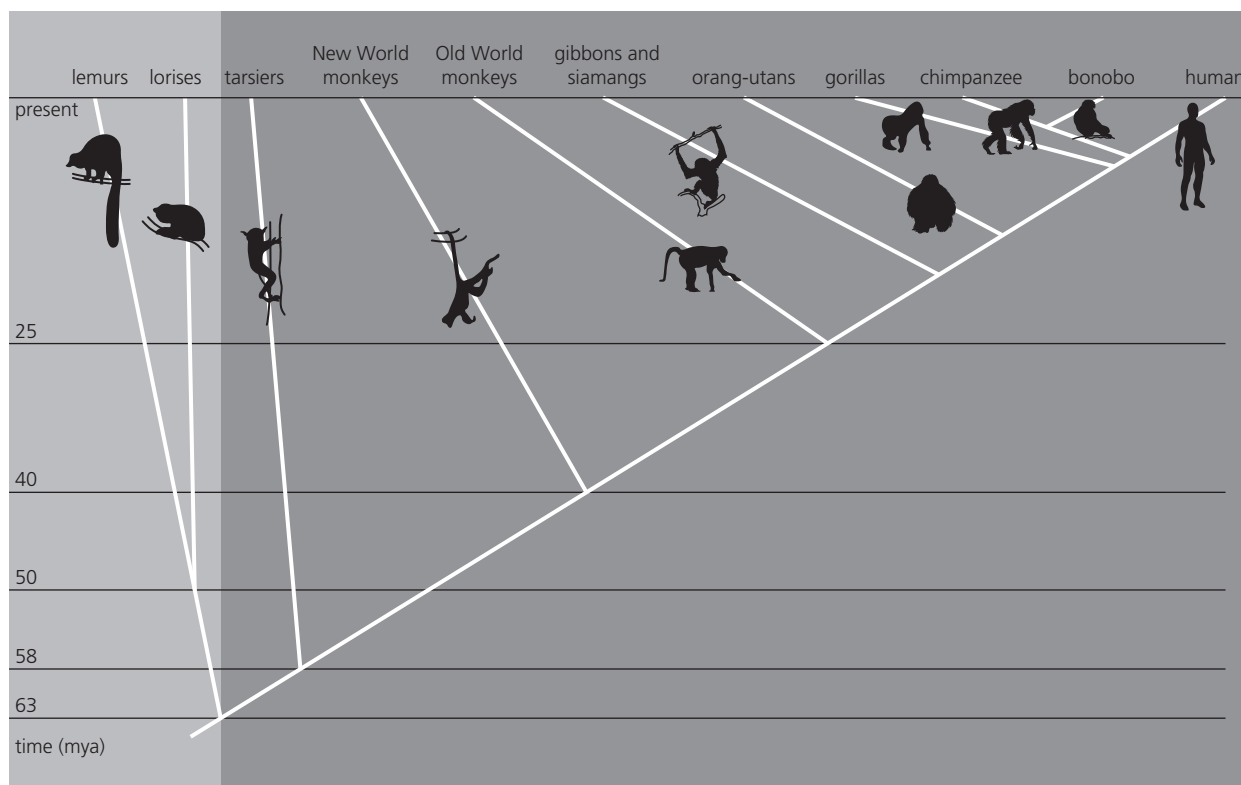
	W	X	Y	Z
A	prokaryote	LUCA	archaea	eukaryote
B	LUCA	eubacteria	archaea	eukaryote
C	eubacteria	archaea	LUCA	prokaryote
D	LUCA	prokaryote	eubacteria	eukaryote

- 5 The figwort family is a large one consisting of many flowering plants that look similar. For what reason have some members of the family been reclassified into a new family?
- A Cladistic analysis shows the differences in flower structure to be fewer than the shared similarities
 - B DNA analysis shows the similarities in flower shape to be a product of convergent evolution
 - C DNA analysis shows some of the families to have suffered recent mutations in only one gene
 - D DNA analysis shows the similarities between the seed dispersal strategies to be a product of divergent evolution

Standard Level Paper 1, Time Zone 2, May 18, Q23

Paper 2 (HL only)

- 1 Analyse the following cladogram, showing evolutionary relationships between humans and other primates.

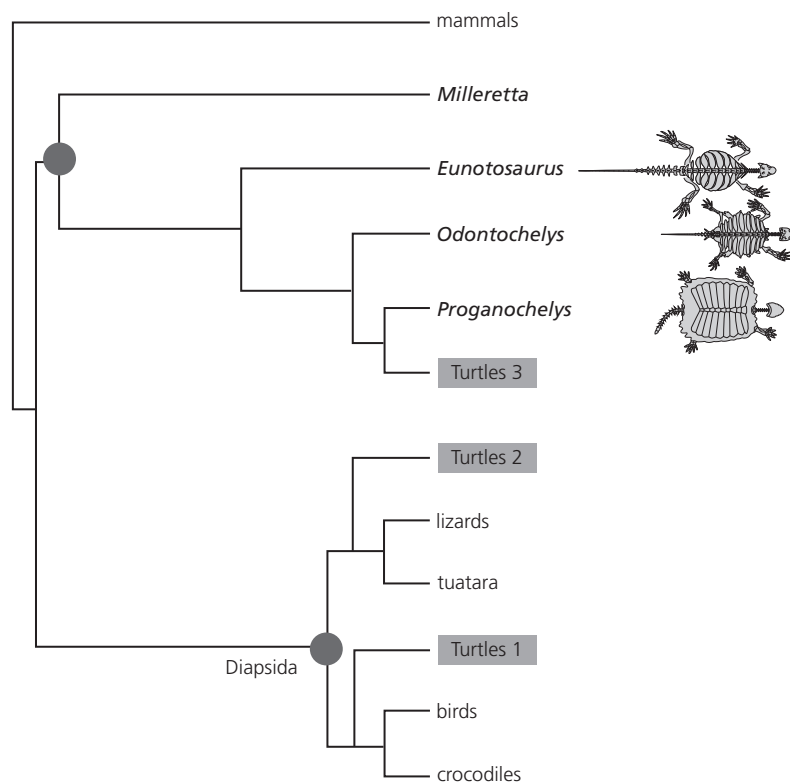


- a Which species are most distantly related to humans? [1]
- b Describe the relationship between lemurs and lorises and the other primate groups. [2]
- c Describe and suggest reasons for the relationship between Old World and New World monkeys. [3]
- 2 The scientific name of the Arizona mud turtle is *Kinosternon arizonense* and for the yellow mud turtle it is *Kinosternon flavescens*.
- a State what is meant by the binomial system of naming living organisms. [2]
- b State if these two turtles belong to the same i) class ii) genus iii) species. [3]
- c *Sophora flavescens* is the scientific name of a different organism. State if this particular species has some evolutionary relationship with the yellow mud turtle based on their scientific names. [2]
- d Outline with a named example how scientists use the binomial system to avoid confusion. [2]
- 3 Outline the use of analogous and homologous traits in natural classification. [4]
- 4 Describe what is shown in a cladogram. [3]
- Higher Level Paper 2, Time Zone 0, November 19, Q3a
- 5 Outline the types of evidence that can be used to place a species in a particular clade. [3]
- 6 Living organisms have been placed in three domains: archaea, eubacteria and eukaryote. Distinguish the eukaryote from the archaea. [3]

Eukaryote	Archaea

Standard Level Paper 2, Time Zone 0, November 16, Q5a (modified)

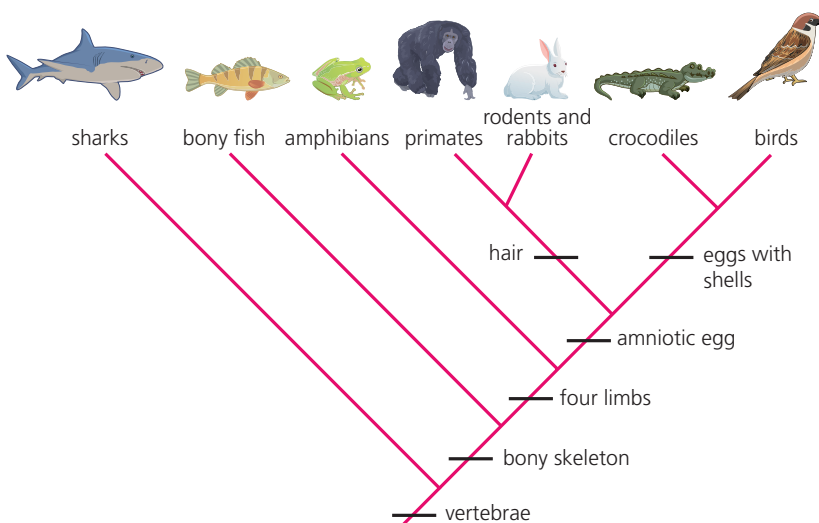
- 7 The following cladogram shows three possible evolutionary routes for the turtle (Turtles 1, Turtles 2 and Turtles 3). The taxa in *italics* are extinct.



- a i State the organism most closely related to the lizards. [1]
 ii Based on the taxa shown, deduce a difficulty in gathering data to study turtle ancestry. [1]
 b i Molecular evidence is often used to construct a cladogram. Describe **one** type of molecular-based evidence to identify members of a clade. [2]
 ii Suggest **one** type of additional evidence that could provide strong support for Turtles 3 as the evolutionary route for turtles rather than Turtles 1 or Turtles 2. [1]
 c Taxonomists aim to place species into genera, families and higher taxa according to their evolutionary origins. This is known as natural classification. [2]
 Explain the usefulness of natural classification in biodiversity research. [2]

Standard Level Paper 2, Time Zone 1, May 17, Q4a–c

- 8 Analyse the following cladogram to deduce evolutionary relationships between vertebrate groups. Then answer the questions below.



- a Which group was the first to evolve? [1]
 b What characteristic separates fish from other vertebrate groups? [1]
 c What feature is characteristic to all groups except sharks? [1]
 d What characteristic separates sharks from bony fish? [1]
 e Which features are the most recently evolved? [1]
 f Which organism will have DNA most similar to the bird? [1]
 9 Explain how cladistics can be used to investigate whether the classification of groups corresponds to evolutionary relationships. [7]

A4.1 Evolution and speciation

Paper 1

- 1 Lamarck and Darwin had different theories for how species changed over time. Which statement is part of Darwin's evolutionary theory?
 - A Changes an organism experienced during its life can be passed on to offspring
 - B The inheritance of acquired characteristics
 - C Change in the heritable characteristics of a population
 - D Complexity arises due to usage or disuse of particular traits
- 2 Which of the following is an example of artificial selection?
 - A Keeping animals in zoos
 - B Breeding of wild mustard to create different types of vegetable
 - C Evolution of antibiotic resistance in bacteria
 - D The pentadactyl limb of vertebrates
- 3 Why are DNA or RNA base sequences or amino acid sequences in proteins considered evidence for evolution?
 - A Closely related organisms have similarities in their base and amino acid sequences
 - B DNA sequences are converted into mRNA
 - C mRNA is used to produce proteins
 - D All organisms contain DNA and proteins
- 4 Birds, bats and humans are all vertebrates with pentadactyl limbs. Birds and bats use their forelimbs to fly whereas humans can use them to lift and manipulate objects. Outline how the bird, bat and human forelimb can be used to illustrate the concept of homologous structures. [2]

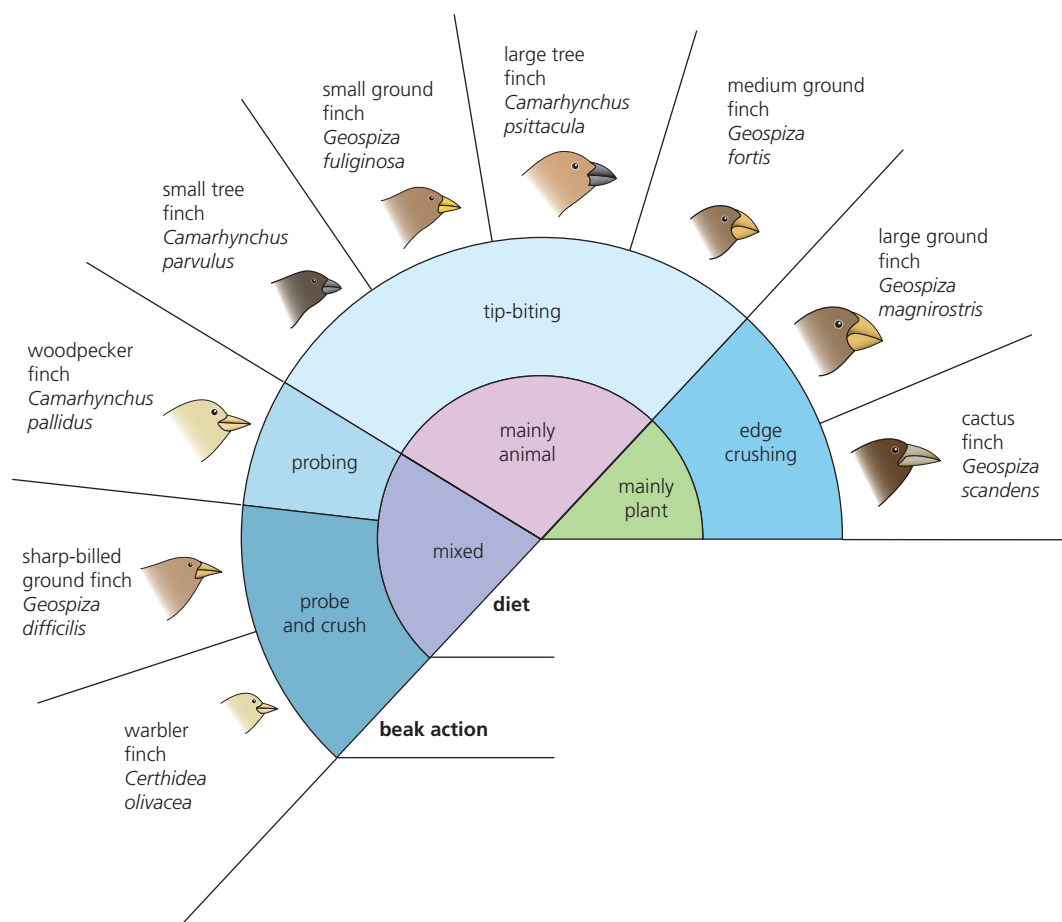
Higher Level Paper 2, Time Zone 1, May 18, Q2b

- 5 Humans have been selectively breeding animals and plants for thousands of years.
 - a Outline how selective breeding provides evidence for evolution. [3]
 - b Compare and contrast selective breeding and natural selection. [4]

(Questions 6–9 HL only)

- 6 Which is the correct definition for sympatric speciation?
 - A Speciation that occurs with geographical separation
 - B Speciation that occurs without geographical separation
 - C Speciation that occurs on islands
 - D Speciation that occurs through selective breeding
- 7 Which of the following is a cause of allopatric speciation?
 - A Sexual dimorphism
 - B Hybridization
 - C Cohabitation
 - D Geographical isolation
- 8 Which statement correctly defines *polyploidy*?
 - A A process resulting from non-disjunction
 - B A process that results in more than two sets of chromosomes in the nuclear genome
 - C A process that results in one diploid and one haploid nucleus
 - D A process that results in four polar bodies

- 9 The figure below shows finches of the subfamily Geospizinae from the Galápagos Islands. Through a series of studies, these endemic finches were found to have evolved by adaptive radiation from an ancestral species that was originally found on mainland South America.



- a Explain how these various species of finches could have arisen. [3]

A new honeycreeper has been found on Daphne Major, one of the Galápagos Islands. Based on its structural and behavioural features (such as song), biologists suggested that the new species is a hybrid of the medium ground finch (*Geospiza fortis*) and the large cactus finch (*Geospiza conirostris*). Genomic sequencing has confirmed this new species of Darwin's finch.

- b Suggest why it is not advisable to determine the phylogenetic relationship of this newfound finch to the rest of the Galápagos Island finches purely based on morphological and behavioural features (form, structure and activity). [1]

Paper 2

- 1 Compare and contrast divergent and convergent evolution. [5]
- 2 Explain, using examples, how evolution may happen in response to environmental change. [7]
- 3 With examples, discuss the factors that contribute to speciation. [7]

(Questions 4–8 HL only)

- 4 Outline how the mixing of alleles between species can be prevented. [4]
- 5 Compare and contrast allopatric and sympatric speciation. [5]
- 6 Describe the process of adaptive radiation. [3]
- 7 Outline how DNA can be studied to determine phylogeny of organisms. [5]
- 8 Explain how polyploidy has led to the rapid evolution of invasive plant species such as knotweed or smartweed. [7]

A4.2 Conservation of biodiversity

Paper 1

- Which statement defines *ecosystem diversity*?
 - The number of species in an area
 - The range of different habitats or number of ecological niches per unit area in an ecosystem
 - The range of biotic and abiotic factors in an area
 - The number of ecosystems in an area
- Look at the four ecosystems listed below. Which ecosystem would have the highest species richness?
 - Desert
 - Rainforest
 - Temperate forest
 - Hydrothermal vent
- Species of beetle were collected in four different habitats. The Simpson's reciprocal index was calculated for each habitat, as shown in the table.

Habitat	Simpson's reciprocal index
1	2.35
2	4.00
3	2.50
4	1.50

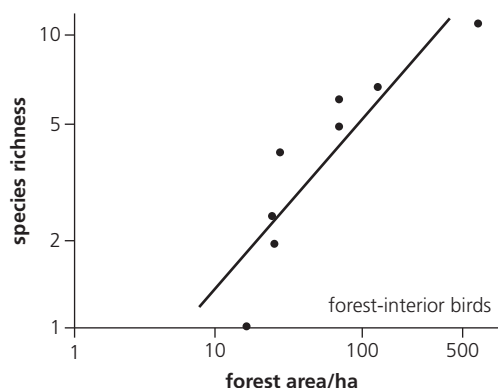
Which statement is correct?

- Habitat 1 has the largest number of species
 - Habitat 1 has the greatest evenness
 - Results for Habitat 1 and Habitat 3 are not significantly different
 - Habitat 4 has the lowest genetic diversity
- What does the evidence of fossils suggest about the number of species on Earth today?
 - The number of species is increasing rapidly
 - The number of species has stabilized
 - There are currently more species alive on Earth today than at any time in the past
 - The number of species is fluctuating
 - Which of the following is an example of an anthropogenic cause of species extinction?
 - An asteroid impact
 - Volcanic eruptions
 - Logging leading to rainforest loss
 - Ice ages

- The North Island giant moa was hunted to extinction by humans. What was a consequence of the extinction of this flightless bird?
 - Less fire frequency
 - Altering vegetation composition and structure
 - Increased seed dispersal
 - Increased urbanization
- In two areas of moorland of the same approximate size, the number of plants was counted. The results are shown in the table.

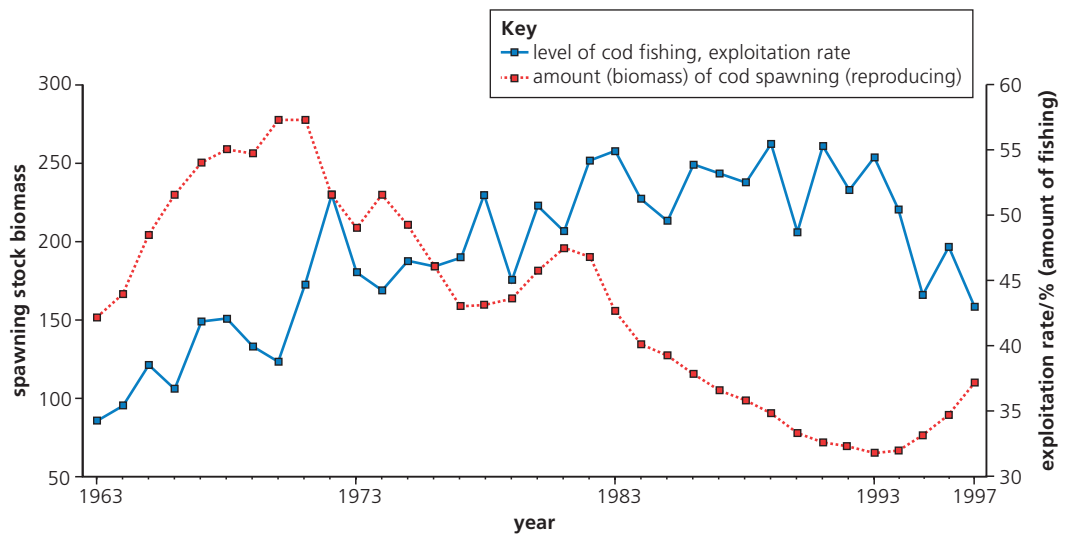
Type of plant	Moorland area 1	Moorland area 2
rosebay willow herb (<i>Chamerion angustifolium</i>)	456	35
sheep's sorrel (<i>Rumex acetosella</i>)	421	1 420
heath bedstraw (<i>Galium saxatile</i>)	386	150
bog asphodel (<i>Narthecium ossifragum</i>)	437	95
Total	1 700	1 700

- Compare and contrast the abundance, richness and evenness of the two areas of moorland. [2]
 - Explain which would have the highest Simpson's reciprocal index. [3]
 - Suggest reasons for the differences in diversity between the two areas. [2]
- Look at the graph below.
 - Explain the relationship between forest area and number of forest-interior bird species. [1]
 - Suggest why there is variation in the data. [1]
 - Suggest what other factors, apart from forest area, would affect the number of forest-interior bird species. [3]



Paper 2

1 The graph below shows the decline of North Sea cod stocks as a result of overfishing.

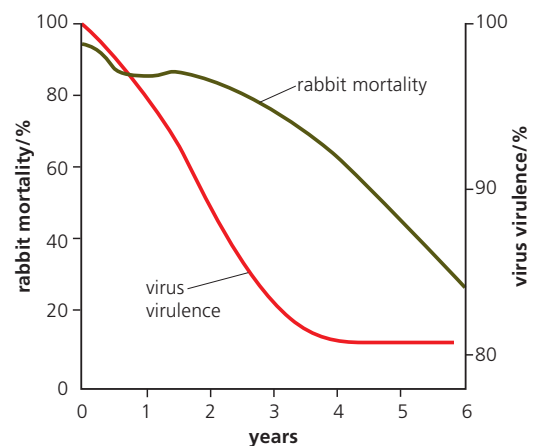


- Describe the changes in the amount of cod spawning between 1963 and 1997. [2]
- Explain the relationship between the level of cod fishing and changes in spawning stock biomass. [3]
- Evaluate the success of fish management techniques over this period. [3]

2 European zoos are devoting much effort to conserving and breeding Amur leopards in captivity. Evaluate the role of ex situ conservation in the protection of Amur leopards. [5]

3 The European wild rabbit was introduced to Australia in 1859. The herbivore spread rapidly. There were no natural predators in Australia to control their number and rabbits quickly overran large parts of the continent. Grassland, available to herds of herbivores, principally cows and sheep, was affected. As a biological control measure, a myxoma virus that had been discovered in South American rabbits (a different species from the European rabbit) was introduced in 1950.

Myxoma virus causes a parasitic disease of rabbits, myxomatosis, but on its original continent, the effects were mild. The changing effects of this virus on rabbit mortality (1950–56) are shown in the graph, as is the resulting change in virulence of the virus. Mortality refers to the death rate seen in the rabbits, and virus virulence to the degree of toxicity or the injury-producing potential of the virus.



- Describe changes in virus virulence over the six-year period. [2]
 - Explain the relationship between virus virulence and rabbit mortality. [3]
 - Evaluate eradication programmes and biological control as measures to reduce the impact of alien species. [3]
- 4 Suggest how a named invasive species may have altered the evolutionary pathways of native species. [7]
- 5 The survival of endangered species is supported by nature reserves and by breeding programmes at zoos and seed banks at botanical gardens. Compare and contrast these approaches, identifying particular strengths and possible drawbacks. [7]

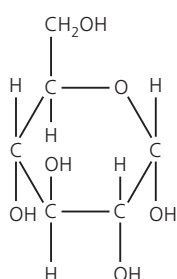
B1.1 Carbohydrates and lipids

Paper 1

- What feature of carbon makes it most suitable as a basis for life?
 - Its abundance on Earth
 - Its bonding properties
 - Its relative atomic mass
 - Its presence in the early atmosphere of the Earth
- Which sugars are both disaccharides?
 - Lactose and fructose
 - Fructose and galactose
 - Maltose and lactose
 - Galactose and maltose
- Monosaccharides are the building blocks of polysaccharides. By which process are polysaccharides formed?
 - Addition of hydrogen
 - Removal of hydrogen
 - Hydrolysis
 - Condensation

Standard Level Paper 1, Time Zone 0, November 00, Q5

- What is the molecule shown in the diagram below?

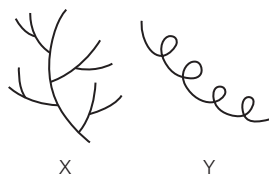


- β -glucose
- Fructose
- α -glucose
- Deoxyribose

- Which of the following statements about polysaccharides can be used to describe both amylopectin and cellulose?
 - Adjacent glucose molecules are rotated by 180°
 - Contains 1,4 glycosidic bonds
 - Polymer of α -glucose
 - II only
 - III only
 - I and II only
 - II and III only
- Which are functions of lipids?
 - Hydrophilic solvent and energy storage
 - Hydrophobic and hydrophilic solvent
 - Thermal insulation and energy storage
 - Thermal insulation and hydrophilic solvent
- What distinguishes cellulose from glycogen and starch?
 - Only cellulose is found in plants
 - Only cellulose is made up of glucose monomers
 - Cellulose is far more branched than starch and glycogen
 - Cellulose has a structural role whereas starch and glycogen function in energy storage

Standard Level Paper 1, Time Zone 1, May 21, Q8

- The diagram shows two polysaccharides, formed from condensation of many glucose molecules. What are the names of X and Y?



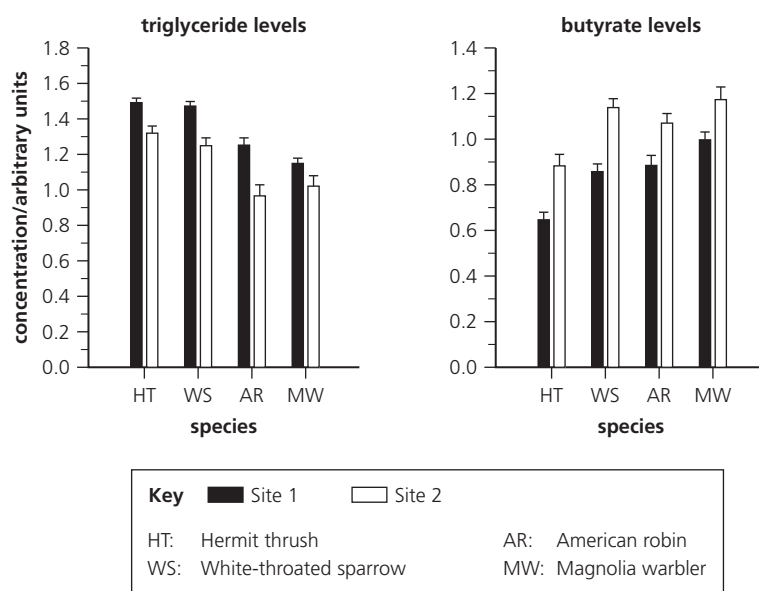
	X	Y
A	glycogen	amylose
B	amylopectin	amylase
C	amylase	glycogen
D	amylose	amylopectin

Standard Level Paper 1, Time Zone 2, May 19, Q7

Paper 2

- 1 Migrating birds must refuel along the way in order to continue flying. A field study was conducted among four different species of migrating birds known to stop at high-quality and low-quality food sites. Birds were captured and weighed at the two sites. Blood samples were taken from the birds to determine nutrient levels in their blood.

Among birds, high triglyceride concentration in blood plasma indicates fat deposition whereas high butyrate concentration in blood plasma indicates fat utilization and fasting. The following data summarizes triglyceride levels and butyrate levels measured for the same groups of birds.

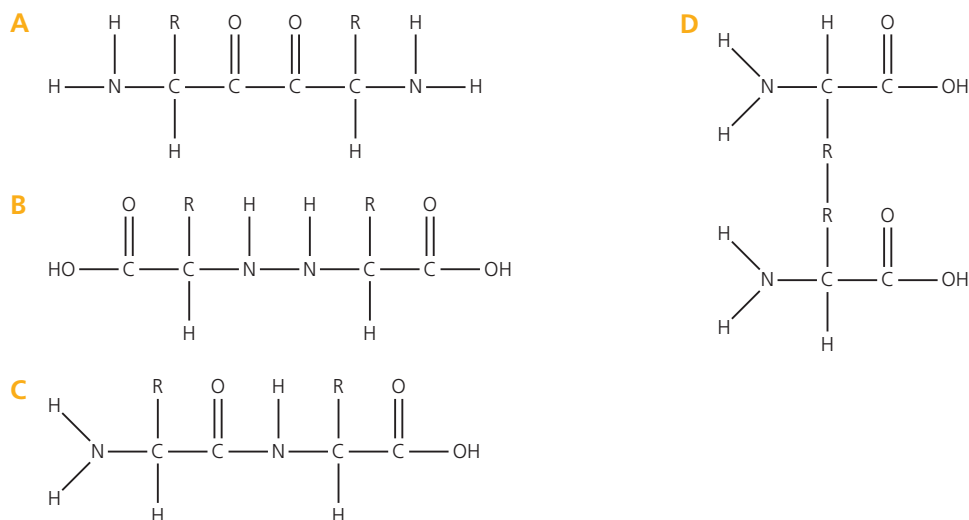


- a Describe, using the triglyceride levels graph, the results at Site 1 and Site 2 for all of the birds. [2]
- b Explain the differences in the triglyceride level and the butyrate level for the hermit thrush at Site 1 and Site 2. [2]
- c Scientists have hypothesized that the food quality is better at Site 1 than at Site 2. Evaluate this hypothesis using the data provided. [2]
- d Suggest **one** advantage and **one** disadvantage for blood sampling rather than weighing birds to assess food quality at stopover sites. [2]
- Higher Level Paper 2, Time Zone 2, May 10, Q1e–h*
- 2 a Distinguish between the structure and function of starch and cellulose in plants. [5]
- b Explain how the structure of cellulose makes it suitable as a component of cell walls. [3]
- 3 Explain the advantages of having both lipid and glycogen as energy stores in the human body. [3]

B1.2 Proteins

Paper 1

1 Which of the following correctly shows a peptide bond between two amino acids?



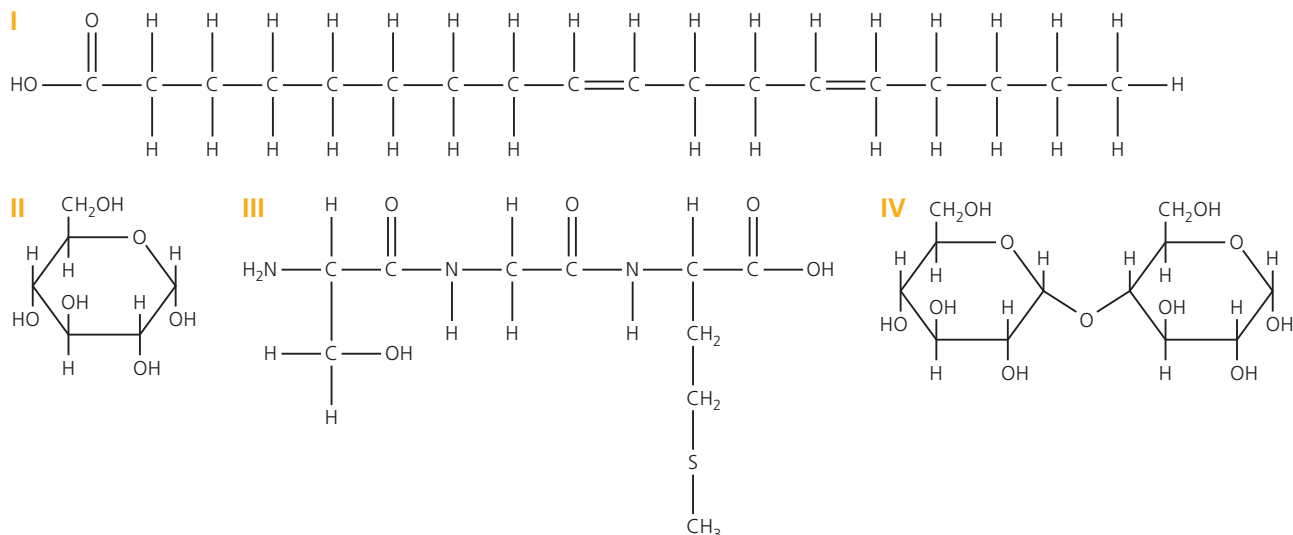
2 How many molecules of water are required to completely hydrolyse a polypeptide made up of 23 amino acids?

- A** 11 **B** 22 **C** 23 **D** 24

3 What is denaturation?

- A** A structural change of a protein that results in the loss of its biological properties
B A change in the genetic code of an organism
C A change in the amino acid sequence of a protein causing a disruption of its three-dimensional shape
D The process by which amino acids are broken down and ammonia is released

4 Which of the molecules contain peptide bonds or are sugar molecules?



	Contain peptide bonds	Are sugar molecules
A	I, III	II
B	III	II, IV
C	I, III, IV	II
D	I	III, IV

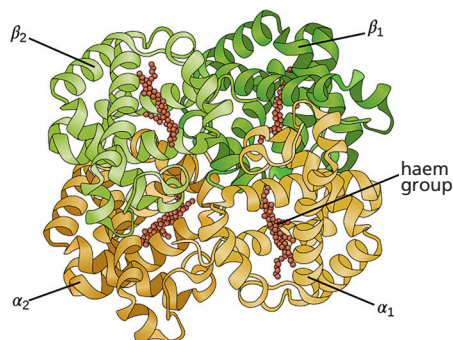
Higher Level Paper 1, Time Zone 0, November 17, Q5

- 5 How does the proteome of a species contain a larger number of proteins than genes that code for these proteins?
- A Some proteins have more than one polypeptide chain
 - B There are genes that code for several proteins
 - C Not all proteins are coded for by the genome
 - D Some proteins are coded for by other proteins

Standard Level Paper 1, Time Zone 1, May 17, Q15

(Questions 6–12 HL only)

- 6 The image shows the structure of the protein haemoglobin.



What level of protein structure bonds the α and β chains together?

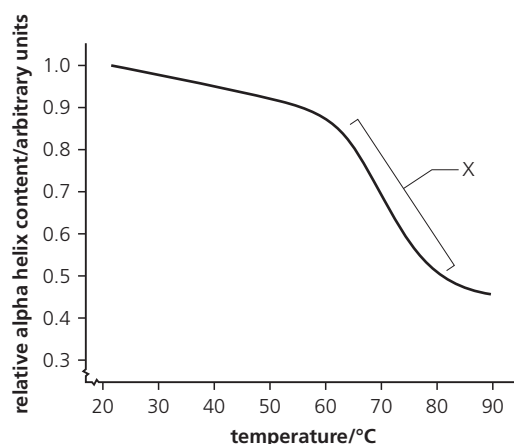
- A Primary
- B Secondary
- C Tertiary
- D Quaternary

Higher Level Paper 1, Time Zone 1, November 21, Q6

- 7 What is found in insulin molecules?
- A Phosphates
 - B Nucleotides
 - C Peptide bonds
 - D Fatty acids
- 8 Which types of interactions are found in a part of a protein with secondary but not tertiary structure?
- I Hydrogen bonds
 - II Disulfide bridges
 - III Ionic bonds
- A I only
 - B I and II only
 - C II and III only
 - D I, II and III

Higher Level Paper 1, Time Zone 1, May 17, Q28

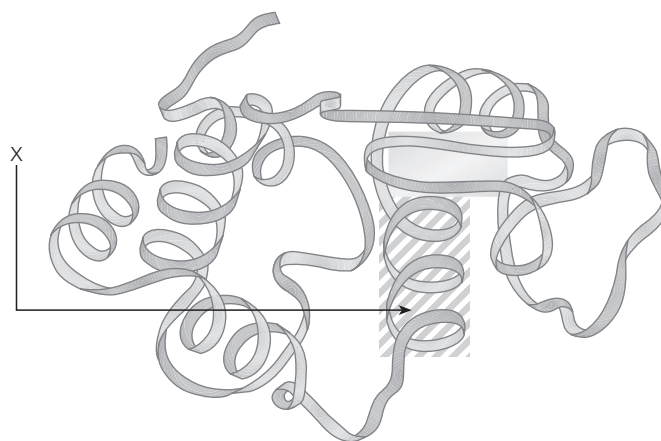
- 9 Scientists have heated a solution containing the protein albumin and measured its relative alpha helix content, shown on the graph. What does the zone labelled X indicate?



- A Rapid increase in beta pleated sheets
- B Rapid formation of hydrogen bonds
- C Rapid increase in denatured protein molecules
- D Rapid decrease in peptide bonds

Higher Level Paper 1, Time Zone 2, May 17, Q9

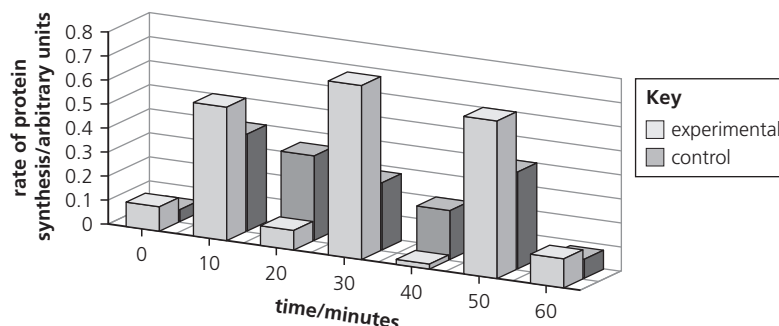
- 10 The image represents a model of a protein. Which level of structure is indicated by X on the image?



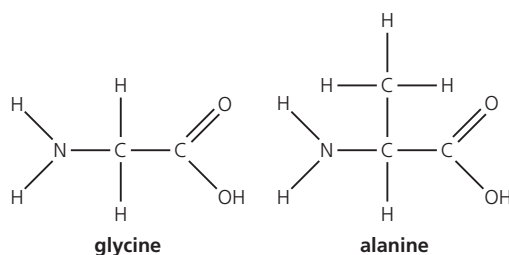
- A Primary
 - B Secondary
 - C Tertiary
 - D Quaternary
- 11 Which statement about the primary structure of a protein is not correct?
- A It is unique to that protein
 - B It is the sequence of amino acids in that protein from the N to C terminus
 - C It is hydrogen bonded
 - D It determines the three-dimensional shape of the folded protein molecule
- 12 Which statement refers to the quaternary structure of collagen?
- A Each polypeptide chain takes the form of an extended helix
 - B Every third amino acid is glycine
 - C Many triple helices, with covalent cross-links, lie parallel with each other, forming fibrils
 - D Three helical polypeptide chains wind round each other to form a right-handed rope-like structure

Paper 2

- 1 Cadmium ions are poisonous to most bacteria. However, some bacteria are able to resist the toxic effect by producing stress proteins. Scientists investigated the production of these proteins in *Vibrio* sp. bacteria by giving them cadmium chloride solution for up to 60 minutes. The graph shows the synthesis of all proteins (measured in arbitrary units) for these bacteria and control bacteria which were not exposed to the cadmium chloride solution.



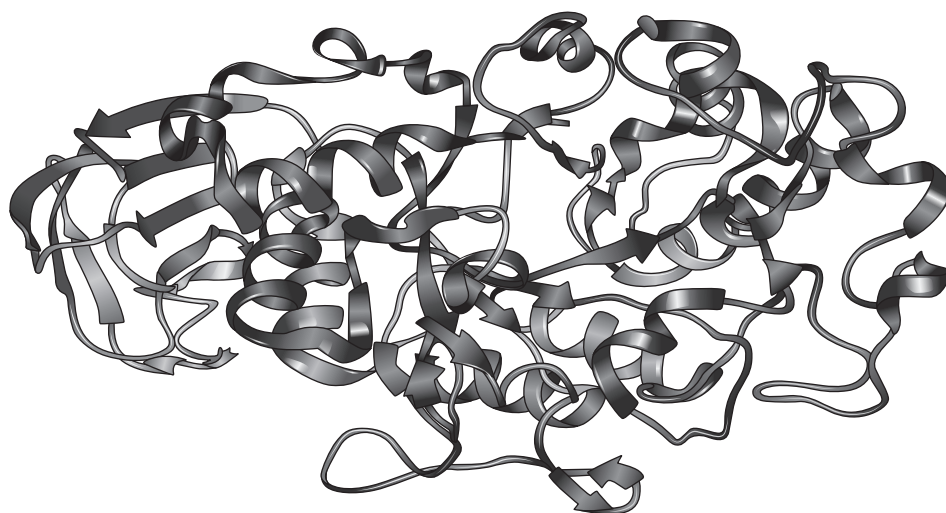
- a Identify the rate of protein synthesis in the control group at 40 minutes. [1]
- b Identify any pattern in the rate of protein synthesis in the experimental group throughout the experiment. [2]
- c Compare and contrast the rate of protein synthesis in both groups. [3]
- 2 a Define the term *proteome*. [1]
- b Identify the location in the cell where polypeptides are synthesized from amino acids. [1]
- c A short polypeptide is comprised of five amino acids. Calculate the possible number of different amino acid sequences for this polypeptide, assuming that 20 amino acids are available for protein synthesis. [1]
- 3 a Draw a molecular diagram of an amino acid to show its general structure [3]
Standard Level Paper 2, Time Zone 2, May 17, Q5a
- b Outline the range of functions of proteins in cells. [5]
Standard Level Paper 2, Time Zone 1, May 21, Q6c
- 4 Explain how proteins are denatured by extreme pH and heat. [4]
- 5 Explain why the shape of globular proteins that are enzymes is important in enzyme action. [3]
- 6 The diagram below shows the structure of the amino acids glycine and alanine.



- a On a copy of the diagram, draw a box to identify the R-group of alanine. [1]
- b Draw a labelled diagram to show the reaction between alanine and glycine to form a dipeptide. [3]

(Questions 7–11 HL only)

7 The diagram shows alpha amylase.

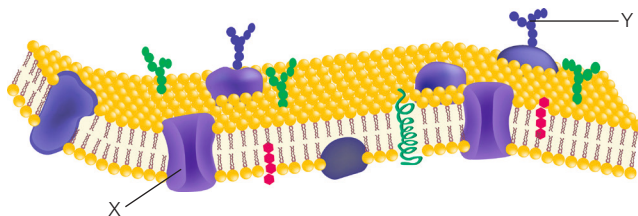


- a Explain the secondary structure of this protein molecule. [3]
Higher Level Paper 2, Time Zone 2, May 18, Q4a
- b Describe the impact of primary structure on the form and function of proteins. [3]
- 8 Explain how chemical diversity in the R-groups of amino acids is the basis for the immense diversity in protein form and function. [5]
- 9 Outline the effect of polar and non-polar amino acids on the tertiary structure of proteins. [4]
- 10 Distinguish between conjugated and non-conjugated proteins. [3]
- 11 Explain the relationship between form and function in globular and fibrous proteins. [7]

B2.1 Membranes and membrane transport

Paper 1

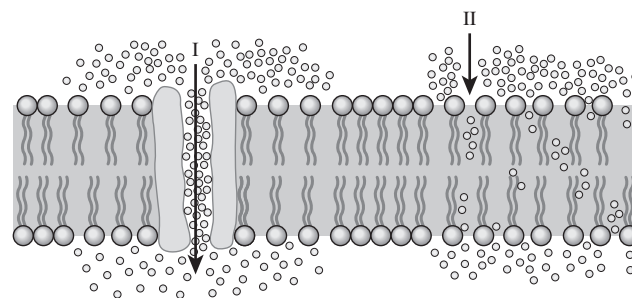
- 1 The diagram below shows a plasma membrane. What are the correct names for structures X and Y?



	X	Y
A	phospholipid	integral protein
B	channel protein	glycocalyx
C	extrinsic protein	fatty acid
D	phosphate head	fatty acid tail

- 2 Which features of phospholipids give them their amphipathic properties?
- A Acidic phosphate groups and basic lipids
 B Basic phosphate groups and acidic lipids
 C Hydrophobic phosphate groups and hydrophilic fatty acids
 D Hydrophilic phosphate groups and hydrophobic fatty acids
- 3 Plasma membranes are fluid due to:
- A The amphipathic properties of phospholipids
 B The water present on the outside of the plasma membrane
 C The integral proteins with polar and non-polar regions interacting with phospholipids
 D Vesicles fusing with the plasma membrane during exocytosis
- 4 Which is the correct definition of osmosis?
- A Movement of water from low to high concentration
 B Movement of water from higher to lower concentration
 C Movement of water from lower water potential to higher water potential through a partially permeable membrane
 D Movement of water from a dilute to more concentrated solute solution through a partially permeable membrane

- 5 What is the role of an aquaporin?
- A Channel protein for water
 B Movement of ions against their concentration gradient
 C Movement of glucose down a concentration gradient
 D Moving water out, not into, a cell
- 6 The diagram below shows a section through a plasma membrane. Which modes of transport across the membrane are shown by I and II?



	I	II
A	osmosis	facilitated diffusion
B	facilitated diffusion	simple diffusion
C	simple diffusion	facilitated diffusion
D	active transport	facilitated diffusion

- 7 The table shows concentrations of potassium ions and sodium ions inside and outside human cells. What explains these concentrations?

Ions	Concentration of ions / $10^{-3} \text{ mol dm}^{-3}$	
	Intracellular	Extracellular
potassium ions	135	4
sodium ions	10	145

- A Potassium ions diffuse in and sodium ions diffuse out
 B Sodium ions diffuse in and potassium ions diffuse out
 C Active transport pumps sodium ions in and potassium ions out
 D Active transport pumps sodium ions out and potassium ions in

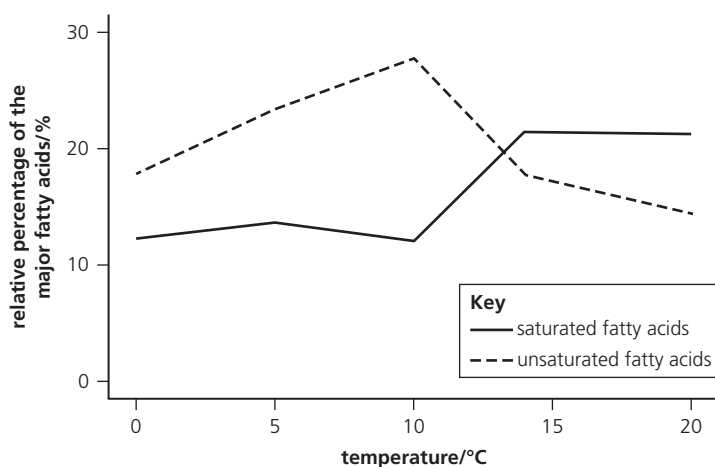
Standard Level Paper 1, Time Zone 2, May 19, Q5

- 8 Which type of transportation happens in the sodium–potassium pump?
- A Simple diffusion
 - B Osmosis
 - C Facilitated diffusion
 - D Active transport

(Questions 9–14 HL only)

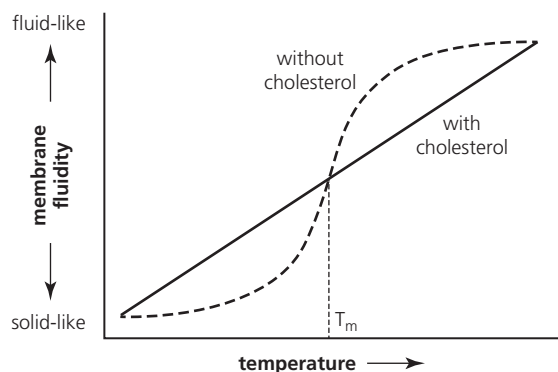
- 9 Which statement applies to cholesterol?
- A It is hydrophobic and found on the inside of the phospholipid bilayer
 - B It is hydrophilic and found outside the phospholipid bilayer
 - C It impacts on membrane fluidity
 - D It is transported in association with glucose in the blood
- 10 Which of the following is used in indirect active transport?
- A Sodium–potassium pumps
 - B Sodium-dependent glucose cotransporters
 - C Voltage-gated sodium channels
 - D Aquaporins
- 11 What is the role of cell-adhesion molecules (CAMs)?
- A Antigen recognition
 - B Attachment of endothelium to basement membrane in capillaries
 - C Used in different types of cell–cell junction
 - D Used in antigen–antibody interactions

- 14 An investigation was carried out on the composition of fatty acids in the cell membranes of a bacterium, *Chryseobacterium frigidisoli* PB4, sampled from Antarctic glacier soils. The habitat of the bacteria is characterized by extremely low temperatures. The effect of changing temperature on fatty acid composition was analysed. Data are presented in the graph below, which shows the relative proportion of unsaturated and saturated fatty acids from *C. frigidisoli* PB4 cultivated at different temperatures



- 12 Nicotinic acetylcholine receptors are an example of:
- A Voltage-gated potassium channels
 - B Voltage-gated sodium channels
 - C Ligand–receptor interaction
 - D Neurotransmitter-gated ion channels

- 13 Cholesterol is found in the cell membrane. An experiment was carried out to investigate the effects of temperature on the fluidity of the membrane. The results are shown in the graph below.



- a Describe the effects of temperature on membrane fluidity. [2]
- b Explain the effects of cholesterol on membrane fluidity at different temperatures. [7]
- c Suggest the advantage of the trends shown by these data for animals with cholesterol in their membranes which live in Arctic areas. [3]

- a Compare and contrast the relative percentage of saturated and unsaturated fatty acids at different temperatures. [3]
- b Explain the trends seen in the data for saturated and unsaturated fatty acids at different temperatures. [7]
- c Suggest reasons why the composition of both fatty acids changes in the way demonstrated by the data. [3]

Paper 2

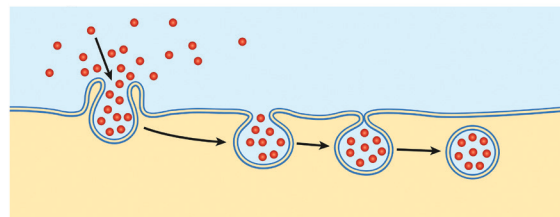
- 1 Draw and label a 2D section of an animal cell membrane. [4]
 - 2
 - a Outline the roles of phospholipids, cholesterol and glycolipids in the plasma membrane at the cell surface. [6]
 - b Outline the functions of proteins in cell membranes. [5]

Standard Level Paper 2, Time Zone 1, May 19, Q7b (modified)
 - 3 Describe four types of membrane transport, including their use of energy. [6]
- Standard Level Paper 2, Time Zone 2, May 19, Q5 (modified)*

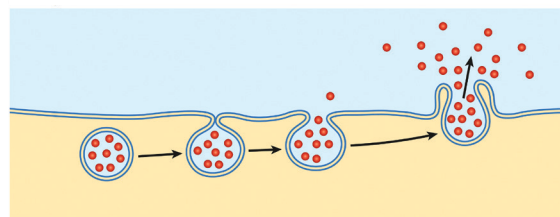
(Question 4 HL only)

- 4 The figure below shows two mechanisms for transporting material across membranes.

X



Y



- a State the names for processes X and Y. [2]
- b Explain the role both processes play in the transport of material into and out from cells. [5]

B2.2 Organelles and compartmentalization

Paper 1

- 1 Which structure found in eukaryotes has a single membrane?
A Nucleus
B Lysosome
C Chloroplast
D Mitochondrion
Standard Level Paper 1, Time Zone 1, May 17, Q1
- 2 What do chloroplasts and mitochondria have in common?
A Both are found in the cells of prokaryotes
B Both contain 70S ribosomes
C Both occur in all eukaryotic cells
D Both are found in a *Paramecium*

(Questions 3–6 HL only)

- 3 The mitochondrion's form relates to its function because:
A It has a folded inner membrane which increases ATP production
B It has a cylindrical shape which is hydrodynamic
C It is small and so has a small surface area compared to its size for diffusion
D It is transparent and so light can pass through
- 4 The advantages of having a membrane surrounding the genetic material of the cell include:
I Protects DNA from other cellular reactions that occur in the cytoplasm
II Allows gene transcription and translation to be kept separate
III Stops DNA from being removed by exocytosis
A I only
B I and II
C I and III
D II and III
- 5 What is the function of the Golgi apparatus?
A Processing and packaging of proteins for export from the cell
B Protein synthesis
C Production of ATP
D Programmed cell death (apoptosis)

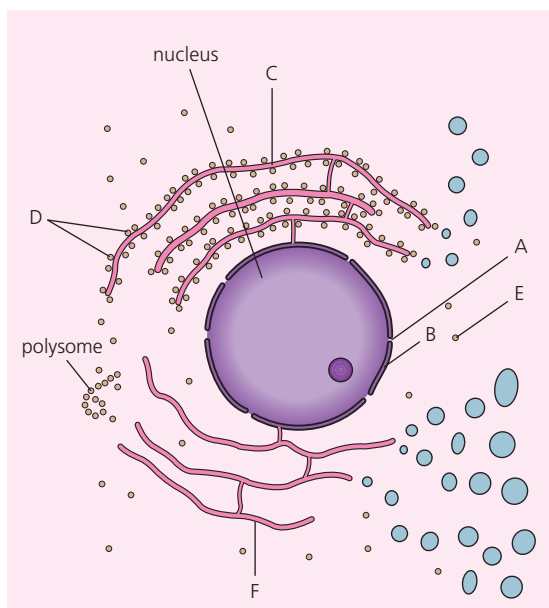
- 6 Adaptations of the chloroplast for photosynthesis include:
I Contains 70S ribosomes
II Large surface area of thylakoid membranes with photosystems
III Small volumes of fluid inside thylakoids
A I only
B I and II
C II and III
D I, II and III

Paper 2

- 1 State the part of the chloroplast where enzymes and substrates of the Calvin cycle are found. [1]
- 2 Define the term *nuclear pore*. [1]
- 3 Diversity is a property of life at all levels of biological organization.
a Outline the diversity of carbon compounds. [7]
b Eukaryotic cells contain a variety of different organelles. Describe the role of compartmentalization in cells. [4]
c Biodiversity is the variety of life in all its forms, levels and combinations. Explain the advantages of classification in biology. [4]
- 4 Outline the advantages of separating the contents of the nucleus from those of the cytoplasm. [5]
- 5 Describe how different organelles are adapted to perform specific functions. [6]
- 6 Explain how the development of ultracentrifugation led to an increased understanding of cell biology. [7]
- 7 Outline the role of membranes in the compartmentalization of cells. [7]

(Questions 8–12 HL only)

8 The figure shows organelles in a eukaryotic cell.



a On a copy of the figure, label structures A–F. [3]

A polysome is identified in the image.

b Describe the role of polysomes in eukaryotic cells. [3]

9 Compare and contrast how the structures of chloroplasts and mitochondria are adapted for their functions. [7]

10 Distinguish the structure and function of free ribosomes and those of the rough endoplasmic reticulum. [4]

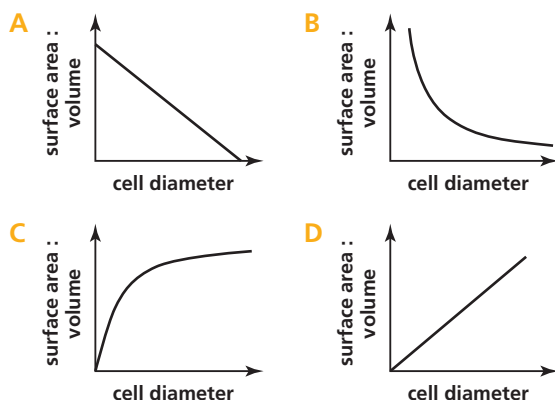
11 Describe the role of clathrin in the formation of vesicles. [4]

12 Explain the functional benefits of the double membrane of the nucleus. [6]

B2.3 Cell specialization

Paper 1

- Which of the following is the property of a totipotent stem cell?
 - Can create, maintain and repair the cells of one particular organ or tissue
 - Can create, maintain and repair cells of several organs or tissues
 - Able to develop into many different types of cells or tissues in the body, except for becoming placental cells
 - Capable of giving rise to any cell type in an organism
- If cells of a multicellular organism have the same genes, how can there be many different cell types in a body?
 - Some genes but not others are expressed in each cell type
 - Cells lose some genes as development occurs
 - Genes do not determine the structure of a cell
 - Cells must practice division of labour in order to survive
- Look at the sizes of the cells below. What is the correct order of size from smallest to largest?
 - Cell I 90 μm
 - Cell II 0.1 mm
 - Cell III 200 nm
 - Cell IV $2 \times 10^{-6} \text{ m}$
 - I $\rightarrow$ II $\rightarrow$ III $\rightarrow$ IV
 - II $\rightarrow$ III $\rightarrow$ IV $\rightarrow$ I
 - III $\rightarrow$ IV $\rightarrow$ I $\rightarrow$ II
 - IV $\rightarrow$ III $\rightarrow$ II $\rightarrow$ I
- Which graph represents the change in cell surface area-to-volume ratio with increasing cell diameter?



Standard Level Paper 1, Time Zone 1, May 19, Q1

- Which of the following is a specialization of female gametes?
 - Motile
 - Small size to increase surface area
 - Large cytoplasm
 - Spherical in shape
- An investigation was carried out on the surface area : mass ratio of different mammal species. Tracings were made of the skins of different mammals, and the masses of the animals recorded.

Table 1 gives the skin areas and masses of each animal.

The surface area : mass ratio is calculated for each animal.

Table 1 Masses and skin area for eight different mammals, arranged in order of size

Mammal	Mass (g)	Area of skin (cm^2)	Surface area/mass
48-hour old gerbil	3	13	4.30
adult male pygmy shrew	5	19	3.80
adult male mouse	29	70	2.41
4-day old hamster	67	139	2.08
adult female gerbil	74	107	1.45
adult mole	76	97	1.28
adult male rat	410	405	0.99
adult female hamster	681	616	0.91
adult grey squirrel	650	444	0.68

- Suggest why mass not volume was used in this investigation. [1]
- Describe the relationship between surface area : mass ratio and the size of animals in the investigation. [1]
- Suggest the effects of increased size on heat loss in mammals. [4]

Table 2 shows the mass, area of skin, and surface area : mass ratio of juvenile (infant) and adult mammals.

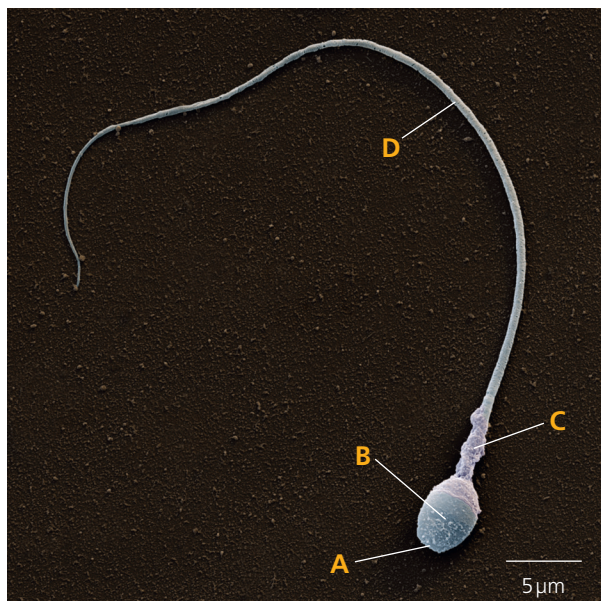
Table 2 Masses and skin area for juvenile and adult mammals of two species

Mammal	Mass (g)	Area of skin (cm^2)	Surface area/mass
baby gerbil	3	13	4.30
adult gerbil	74	107	1.45
baby hamster	67	139	2.08
adult hamster	681	616	0.91

- Describe the change in surface area : mass ratio of juveniles compared to the adult of the same species. [1]
- Suggest how human babies can be treated to overcome the issues identified in part c. [3]

(Questions 7–12 HL only)

- 7 The micrograph shows part of a human sperm cell. Which region of the cell is responsible for the greatest production of ATP?



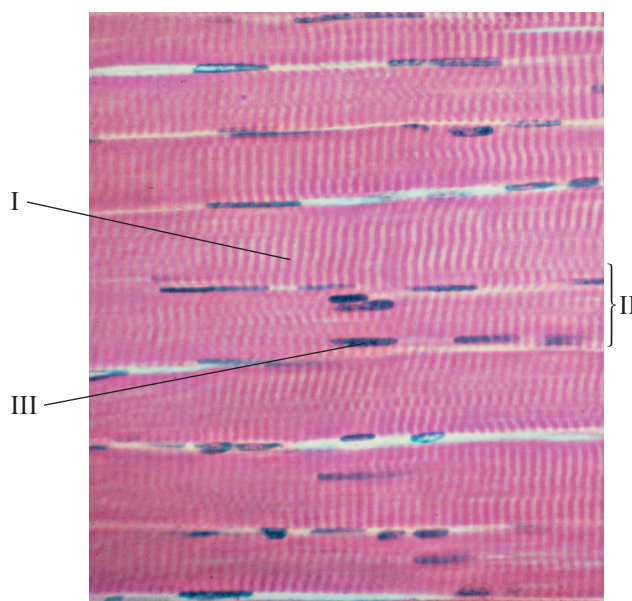
Higher Level Paper 1, Time Zone 1,
November 21, Q40 (modified)

- 8 Where in the body are type I pneumocytes found?
- A Alveoli
 - B Small intestine
 - C Capillaries
 - D Bronchi
- 9 How do respiratory gases cross the membrane of pneumocytes during gas exchange?
- A Facilitated diffusion
 - B Gated-ion channels
 - C Active transport
 - D Simple diffusion
- 10 What feature distinguishes striated muscle fibres from cheek cells, sperm cells and epithelial cells of the small intestine?
- A Mitochondria
 - B Nucleoid regions
 - C Multinucleate structure
 - D Membrane-bound organelles

- 11 In premature babies born earlier than the 30th week of pregnancy, type II pneumocytes are usually not fully developed, so they do not carry out their function normally. What is a possible consequence of this?
- A The number of alveoli reduces
 - B The size of the alveoli increases
 - C Capillary networks do not develop fully and oxygen is not absorbed
 - D Surface tension between alveoli does not decrease and the alveoli stick together

Standard Level Paper 1, Time Zone 2, May 19, Q26

- 12 This light micrograph shows muscle tissue.



- a This muscle is made from repeating dark bands (structure I). State the name of this type of muscle. [1]
- b Identify the structures labelled II and III in the micrograph. [2]
- c Discuss whether the tissue shown in the micrograph consists of cells or not. [2]

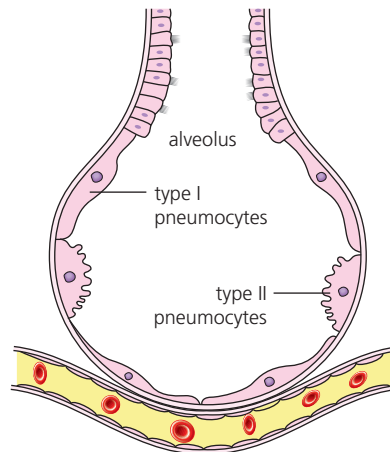
Higher Level Paper 2, Time Zone 0,
November 19, Q5ai–b (modified)

Paper 2

- 1 Outline the properties of stem cells. [3]
- 2 Describe the role of stem cell niches in adult humans. [4]
- 3 Distinguish between totipotent, pluripotent and multipotent stem cells. [3]
- 4
 - a Outline how size is an aspect of cell specialization. [4]
 - b Explain why surface area-to-volume ratio is a constraint on cell size. [5]
- 5 Describe the processes following fertilization that lead to the development of specialized cells. [7]

(Questions 6–9 HL only)

- 6 The diagram shows the structure of an alveolus and an adjacent capillary.



- a
 - i Describe the functions of type I and type II pneumocytes. [2]
 - ii Explain how the form of type I pneumocytes is linked to their function. [3]
 - b Explain how gases are exchanged between the air in the alveolus and the blood in the capillaries. [3]
- 7 Explain how the form of cardiac muscle cells determines their function. [7]
- 8 Compare and contrast the adaptations of sperm and egg cells. [7]
- 9 Using the surface area-to-volume relationship, explain why models are useful artificial representations of natural phenomena. [7]

B3.1 Gas exchange

Paper 1

1 What occurs during inhalation?

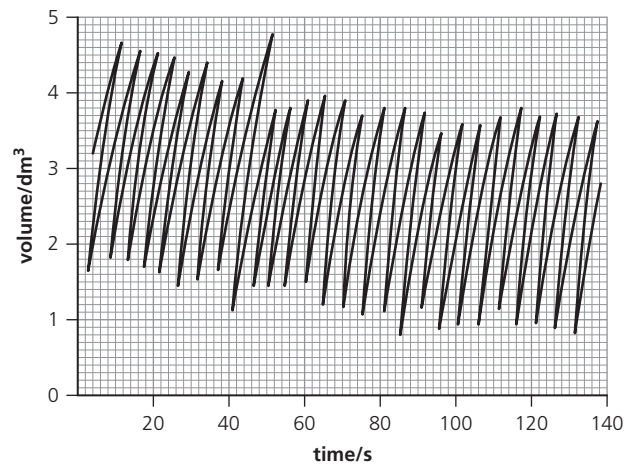
	External intercostal muscles	Movement of ribs
A	relax	fall
B	contract	fall
C	relax	rise
D	contract	rise

Standard Level Paper 1, Time Zone 0, November 21, Q27

2 Which is an adaptation to increase rates of gas exchange in the lung?

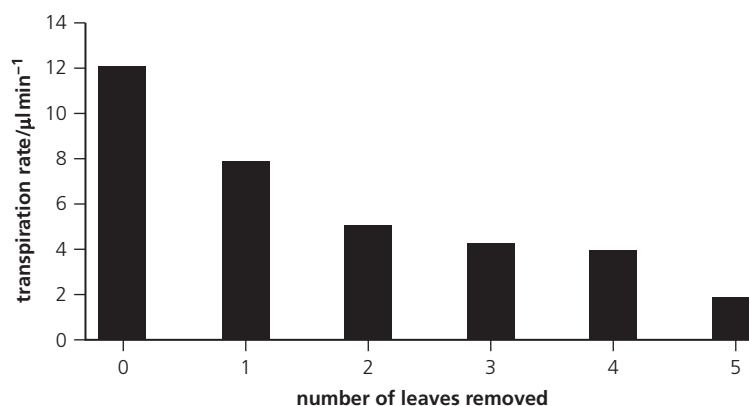
- A Small surface area
- B Dry surface
- C Large number of capillaries
- D Muscular alveoli

3 The graph shows a spirometer trace taken during exercise. What does this spirometer trace show?



- A The breathing rate is 11 breaths per minute
- B The tidal volume is 4 dm^3
- C The inspiratory reserve is 5 dm^3
- D The expiratory reserve is 1 dm^3

- 4 A student designed an experiment to study the transpiration through the leaves of a tomato plant (*Solanum lycopersicum*). Measurements were taken in the initial conditions with five leaves on a tomato shoot and then again after each of the five leaves was removed.

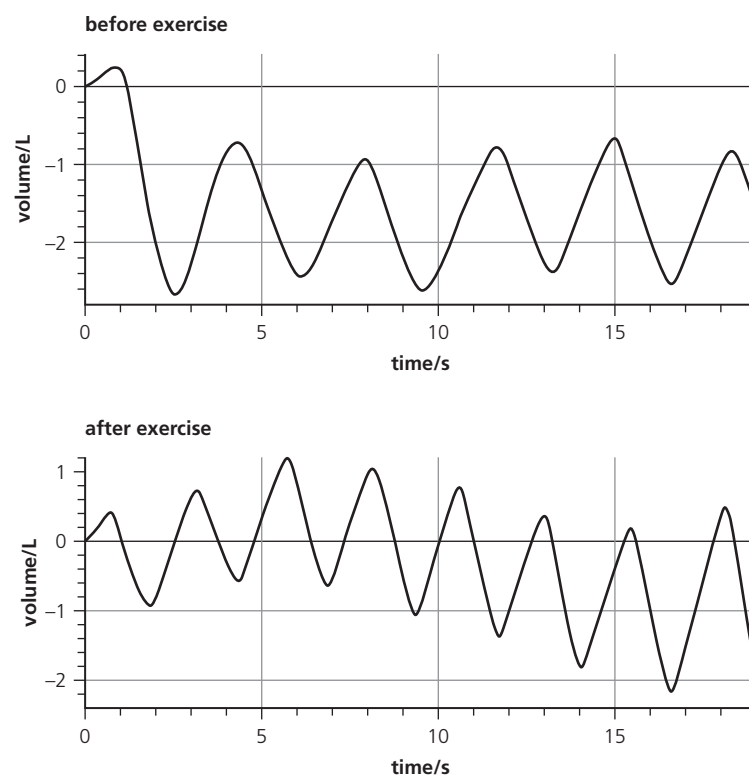


- a i Describe the trend in the data. [1]
 ii Transpiration continued after the fifth leaf had been removed. Suggest what can be concluded. [1]
 b State the independent variable in this investigation. [1]
 c Explain how the results in the graph could have been obtained. [2]

Higher Level Paper 3, Time Zone 0, November 19, Q2a–c

- 5 In an experiment to explore the effect of exercise on ventilation rate, a subject breathed into a data logging sensor that measured air flow.

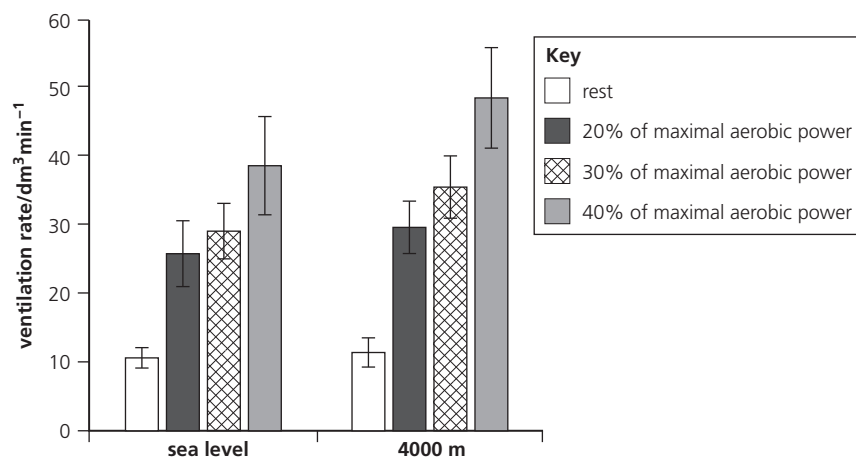
The graphs show the result before the subject exercised and immediately after the exercise had finished.



- a Determine the ventilation rate after exercise. [2]
 b Describe how the mean tidal volume after exercise could be determined using the graph. [2]
 c Predict, with a reason, the effect of exercise on the rate of cell respiration. [1]
 d Identify a muscle responsible for increasing the volume of the chest cavity. [1]

Standard Level Paper 3, Time Zone 2, May 18, Q3a–d

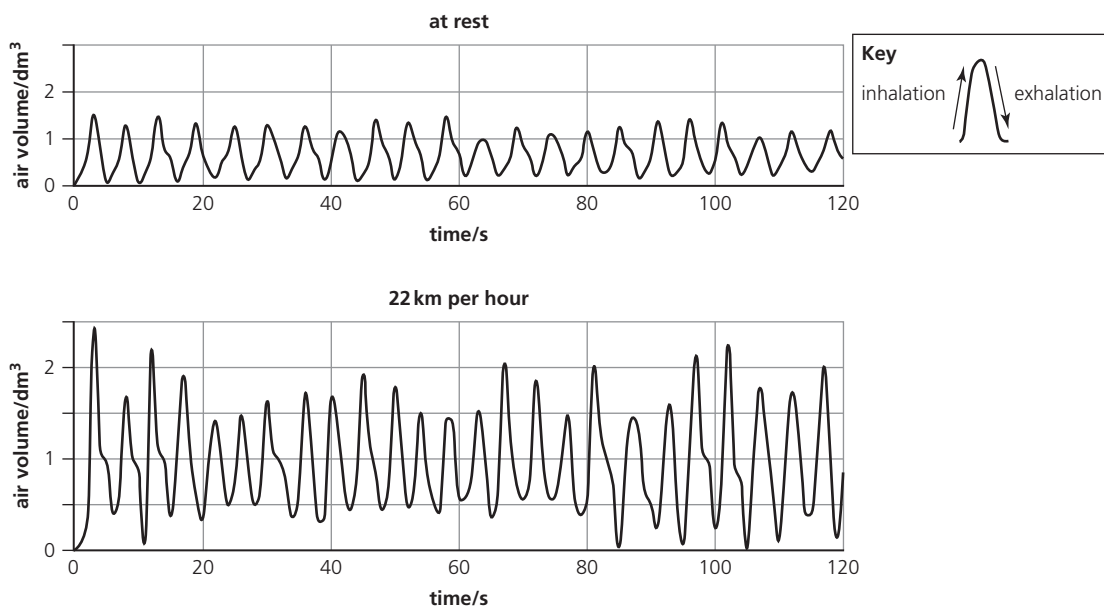
- 6 A study was conducted on 25 healthy, non-smoking males to look at the effect of exercise and altitude on ventilation rate. Subjects were first asked to rest in a sitting position for six minutes. They then pedalled for three periods of six minutes at increasing exercise intensity: at 20%, 30% and 40% of their maximal aerobic power. The entire study was conducted either in normal sea level oxygen conditions or in lower oxygen conditions simulating an altitude of 4000 m. The results are shown in the bar chart.



- a State **one** other variable that should have been controlled in this study. [1]
b Compare and contrast the effect of increasing exercise intensity at sea level and at an altitude of 4000 m. [2]
c Outline how ventilation rate could have been monitored in this study. [2]

Standard Level Paper 3, Time Zone 2, May 19, Q3a–c

- 7 A spirometer was used to measure the ventilation rate of a person at rest and pedalling at 22 km per hour on an exercise bike.



- a Calculate the difference in ventilation rate between resting and exercising. [1]
b Explain the change in the tidal volume during exercise. [3]

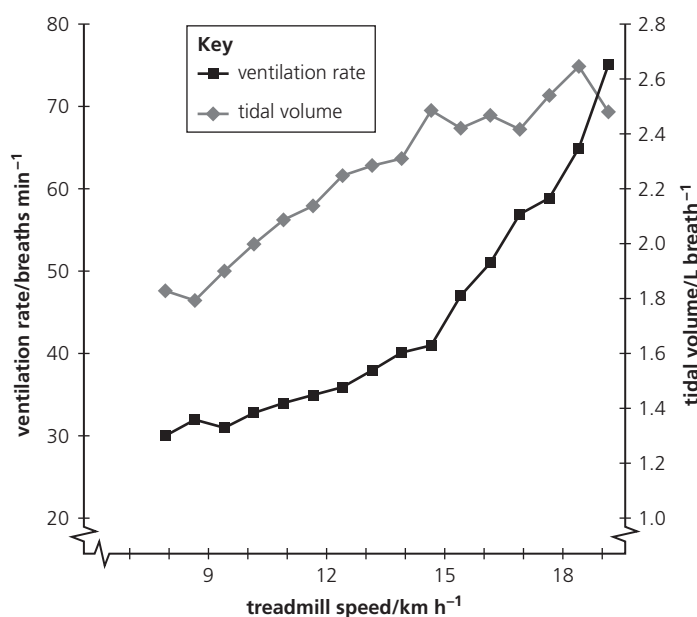
Standard Level Paper 3, Time Zone 1, May 17, Q3a–b

(Questions 8 and 9 HL only)

- 8 Adaptations of foetal and adult haemoglobin for the transport of oxygen include:
- I Cooperative binding of oxygen to haem groups
 - II Allosteric binding of carbon dioxide
 - III Competitive inhibition of antioxidant enzymes
- A I only
 B I and II
 C I, II and III
 D I and III
- 9 What effect does an increase in carbon dioxide have on haemoglobin?
- A Decreased dissociation of oxygen
 B Increased dissociation of oxygen
 C Decreased haemoglobin synthesis
 D Increased breakdown of the haem group

Paper 2

- 1 The graph shows the ventilation rate and tidal volume of a well-trained runner during exercise on a treadmill. The tidal volume is the volume of air being moved in and out of the lungs in each breath.



- a State the apparatus used to measure the tidal volume. [1]
- b Calculate the total volume of air inhaled during one minute during the highest velocity of the treadmill in this test, giving the units. [2]
- c Compare and contrast the effect of increasing treadmill speed on the ventilation rate and tidal volume in this runner. [2]

Higher Level Paper 3, Time Zone 1, May 18, Q2a–c

- 2 Describe the process of inhalation. [4]
- 3 Explain the process of gas exchange taking place in the alveoli. [7]

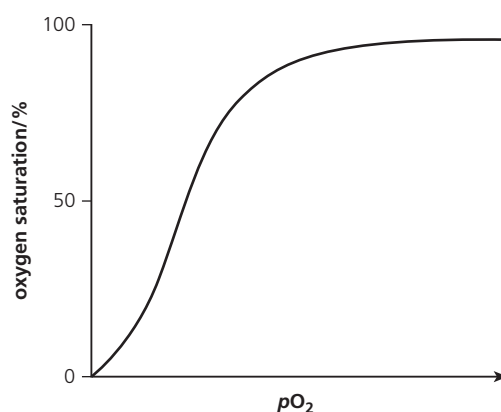
Standard Level Paper 2, Time Zone 1, May 21, Q7b

- 4 Adult humans may absorb more than 500 litres of oxygen per day. Explain how gas exchange is maintained in the human respiratory system. [7]

Higher Level Paper 2, Time Zone 0, November 18, Q6c

(Questions 5–7 HL only)

- 5 The graph below shows the oxygen dissociation curve at a low CO₂ concentration.



- a An increase in metabolic activity results in greater release of CO₂ into the blood. On a copy of the graph, draw the oxygen dissociation curve during intense exercise when the CO₂ concentration of the blood is high. [1]
- b Explain how the increase in CO₂ concentration affects the release of oxygen to respiring cells. [2]
- Higher Level Paper 3, Time Zone 1, May 17, Q21bi–ii*
- 6 Explain how oxygen dissociation curves can be used to represent the affinity of haemoglobin for oxygen at different oxygen concentrations. [5]
- 7 Outline how an increase in carbon dioxide causes increased dissociation of oxygen and how this benefits actively respiring tissues. [7]

B3.2 Transport

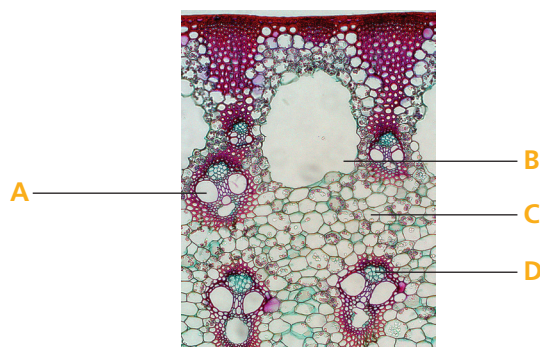
Paper 1

1 What is a property of arteries?

- A Arteries have elastic walls
- B Arteries have valves
- C All arteries carry oxygenated blood
- D Arteries receive blood from the atria

Standard Level Paper 1, Time Zone 1, May 21, Q27

2 The image shows part of a section through the stem of a non-woody plant. Where does transport of sucrose occur?



Higher Level Paper 1, Time Zone 2, May 21, Q33

3 Which process is most responsible for movement of water from roots to leaves of a plant on a hot sunny day?

- A Active translocation of mineral ions in roots
- B Active transport of organic compounds into sieve tubes
- C Raised hydrostatic pressure gradients
- D Evaporation of water from mesophyll cell walls

Higher Level Paper 1, Time Zone 0, November 19, Q32

4 What is an advantage of capillary walls being one cell thick in the systemic circulation?

- A To allow carbon dioxide to diffuse into tissues
- B To allow glucose to diffuse out of tissues
- C To allow oxygen to diffuse into tissues
- D To allow urea to diffuse into tissues

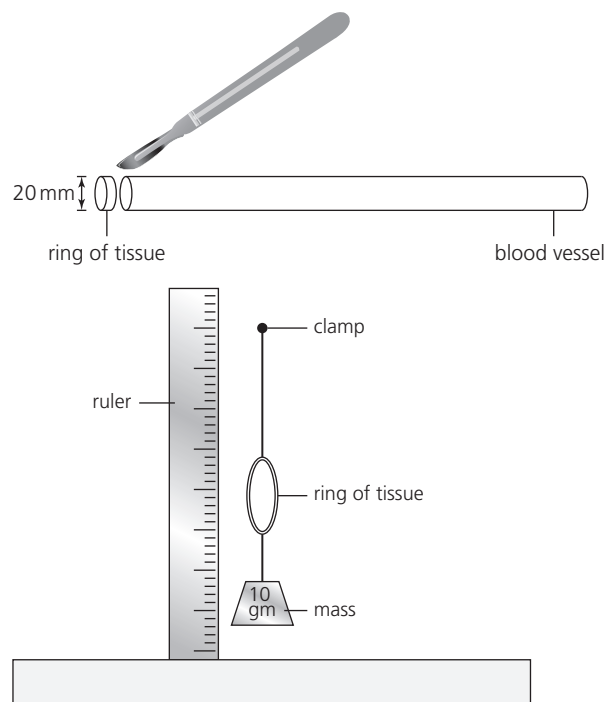
5 Which process and cause are responsible for water uptake by the roots?

	Processes	Cause
A	simple diffusion	solute concentration in the root lower than in the soil
B	osmosis	solute concentration in the root greater than in the soil
C	osmosis	solute concentration in the root lower than in the soil
D	cohesion	solute concentration in the root greater than in the soil

Higher Level Paper 1, Time Zone 1, May 17, Q32

6 In an investigation to compare the elasticity of arteries and veins, rings of the same diameter (20 mm) of artery and vein tissue were cut from blood vessels obtained from a mammal.

Each ring was attached to a clamp. Multiple masses of 10 g were added and removed. The vertical diameter of the artery and the vein was measured, both with the mass and once the mass had been removed. The results are shown in the table.



Mass / g	Diameter of vein / mm		Diameter of artery / mm	
	With mass	Mass removed	With mass	Mass removed
0	20	20	20	20
10	26	26	26	22
20	34	33	30	23
30	38	36	35	23
40	40	37	38	24

- a State the independent and dependent variables in this experiment. [2]
- b State **one** feature of the rings that has to be kept constant apart from their initial diameter. [1]
- c Explain the differences between the results shown for vein and artery. [3]

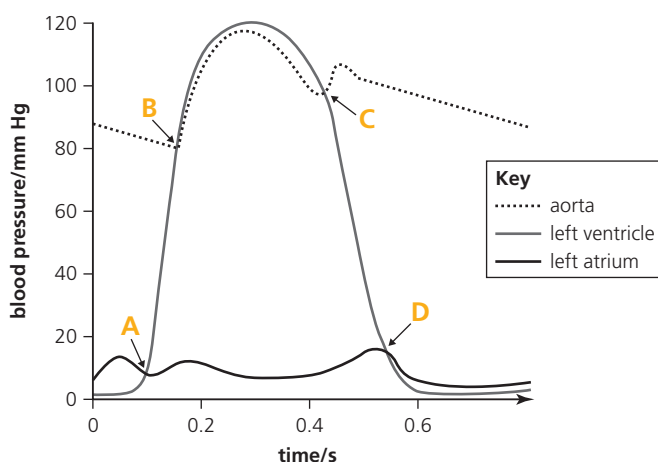
Standard Level Paper 3, Time Zone 0, November 20, Q2a–c

(Questions 7–12 HL only)

- 7 The mammalian heart has four chambers: right atrium, left atrium, right ventricle and left ventricle. The sinoatrial node is located in the wall of one of these chambers. Which chamber is it?
- A Right atrium C Left atrium
B Right ventricle D Left ventricle
- 8 What blood flow does the right semilunar valve prevent?
- A Backflow of blood to the right atrium during ventricular contraction
B Blood flowing from the aorta back into the heart when the ventricle is filling
C Blood flowing from the pulmonary artery to the right ventricle when the heart is relaxing
D Blood flowing from the right atrium to the vena cava when the right atrium contracts

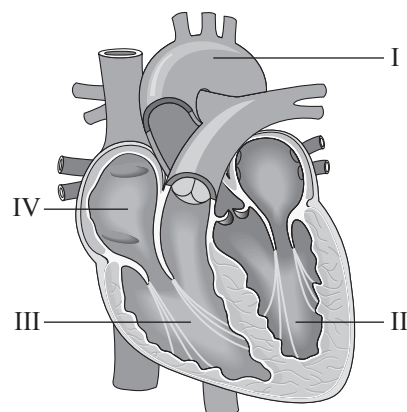
Standard Level Paper 1, Time Zone 1, May 21, Q29

- 9 The diagram shows changes in pressure in the left atrium, left ventricle and aorta during a single cardiac cycle. At what point during the cycle does the atrioventricular valve close?



Standard Level Paper 1, Time Zone 2, May 21, Q25

- 10 The diagram shows the human heart. After a red blood cell picks up oxygen in the lungs, which sequence shows the path it could take when passing through the heart during its circuit of the body?

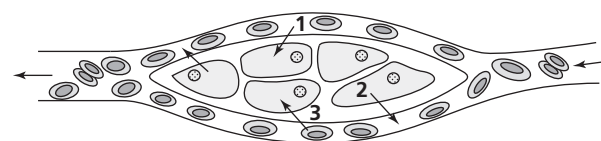


- A I → II → III → IV
B II → I → IV → III
C IV → III → I → II
D IV → III → II → I

Standard Level Paper 1, Time Zone 0, November 19, Q26

- 11 In which blood vessel connected to the heart does blood have the lowest carbon dioxide concentration?
- A Pulmonary vein
B Vena cava
C Pulmonary artery
D Hepatic portal vein

- 12 The diagram shows red blood cells and undifferentiated tissue cells. Diffusion of oxygen from blood cells to tissue cells is represented by arrow 3 in the diagram. What molecules are shown diffusing by arrow 1 and arrow 2?

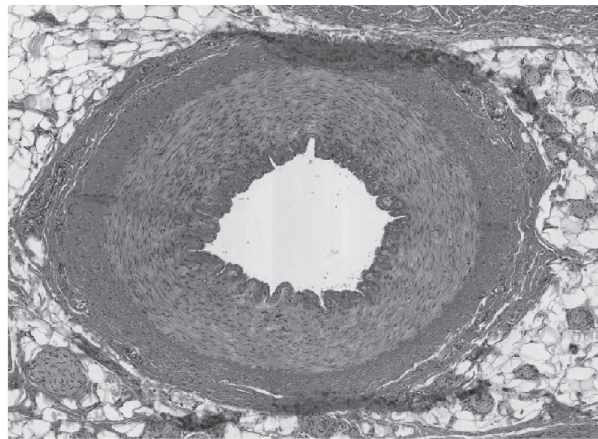


Arrow 1	Arrow 2
A carbon dioxide	urea
B water	glucose
C glucose	carbon dioxide
D fatty acids	amino acids

Standard Level Paper 1, Time Zone 0, November 17, Q25

Paper 2

- 1 This micrograph shows a transverse section of an artery.



×100

- a Outline how the specialized structures of arteries help them to achieve their functions. [3]

Standard Level Paper 2, Time Zone 0, November 21, Q4a (modified)

- b Distinguish between the structures of arteries, veins and capillaries. [6]

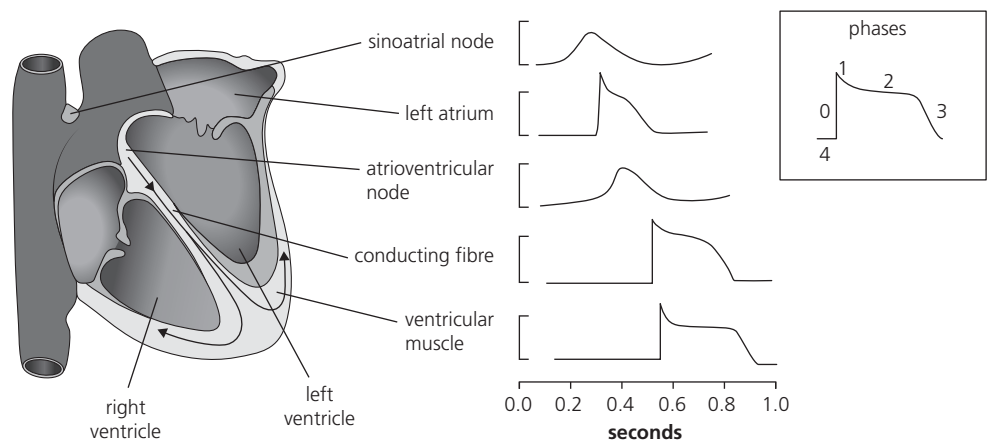
- 2 Plants have developed efficient methods for transport of water and organic materials. Distinguish between the xylem and phloem of plants. [5]

- 3 Explain the processes that cause water to move from the roots of plants to their leaves. [7]

(Questions 4–8 HL only)

- 4 a State the name of the valves that prevent blood flowing from the arteries back into the heart. [1]

The drawing shows the typical action potential waveforms with the different phases of the cardiac cycle recorded in different regions of a human heart.



- b Distinguish between the different phases of the cardiac cycle in the atria and in the ventricular muscle. [2]

Standard Level Paper 3, Time Zone 2, May 19, Q18b–c

- 5 Compare and contrast the single circulation of bony fish and the double circulation of mammals. [4]

- 6 Outline the control mechanism of the heart rate. [5]

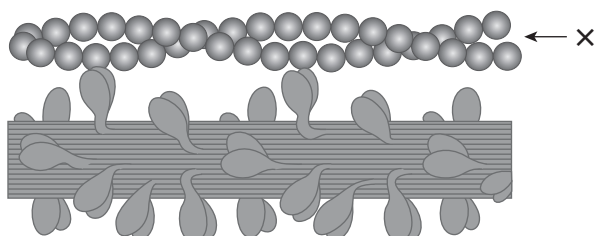
- 7 Outline how root pressure is generated in xylem. [5]

- 8 Explain the formation and reuptake of tissue fluid. [7]

B3.3 Muscle and motility (HL only)

Paper 1 (HL only)

- 1 The diagram shows structures involved in contraction of a sarcomere. What is X?



- A Myosin filament
- B Sarcomere
- C Actin filament
- D Myofibril

Higher Level Paper 1, Time Zone 2, May 21, Q38

- 2 What is the role of calcium ions in muscle contraction?

- A To enable actin to expose binding sites on myosin
- B To bind to troponin, exposing binding sites on actin
- C To prevent an action potential in the muscle membrane
- D To bind to tropomyosin, blocking binding sites on actin

Higher Level Paper 1, Time Zone 0, November 20, Q38

- 3 What is a similarity between human and insect muscles?

- A They are attached to an exoskeleton
- B They work as antagonistic pairs
- C The flexor muscles straighten the joint
- D They move bones

Higher Level Paper 1, Time Zone 0, November 19, Q38

- 4 What is the role of the joint capsule in a hip joint?

- A It seals the joint to retain the synovial fluid
- B It provides a point of attachment for muscles
- C It produces cartilage to reduce friction during movement
- D It directs the formation of bone tissue during growth and development

Higher Level Paper 1, Time Zone 1, May 19, Q38 (modified)

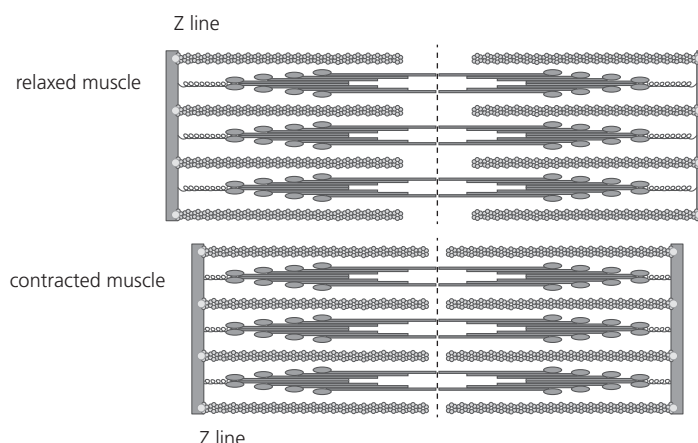
- 5 Which process is part of the mechanism that controls muscle contraction?

- A Troponin enables actin heads to attach to ATP and slide along myosin
- B Myosin heads attach to troponin and tropomyosin pulls on actin filaments
- C Tropomyosin attaches to calcium and breaks the bond between actin and myosin
- D Calcium frees actin filaments for myosin heads to attach

Higher Level Paper 1, Time Zone 0, May 16, Q38

- 6 The diagram shows two states of skeletal muscle, relaxed and contracted.

Which process is part of muscle contraction?



- A Myosin filaments cause the actin filaments to shorten
- B Ca^{2+} from the sarcoplasmic reticulum binds to the myosin heads
- C ATP provides energy for the movement of the myosin heads
- D Ca^{2+} binds to tropomyosin and uncovers troponin

Higher Level Paper 1, Time Zone 2, May 18, Q38

Paper 2 (HL only)

- 1 Figure 1 is a diagram that shows part of a muscle myofibril.

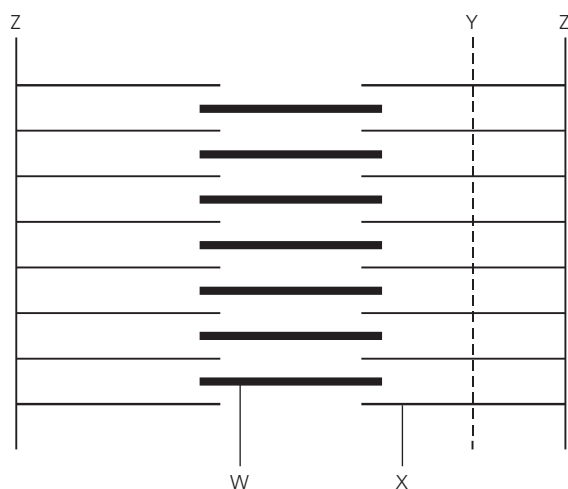


Figure 1

- a Name the protein present in the filaments labelled W and X. [1]
- b Figure 2 shows the cut ends of the protein filaments when the myofibril was cut at position Y. Figure 3 shows the protein filaments when the myofibril was cut at the same distance from a Z line at a different stage of contraction. Explain why the pattern of protein filaments differs in Figure 2 and Figure 3. [2]

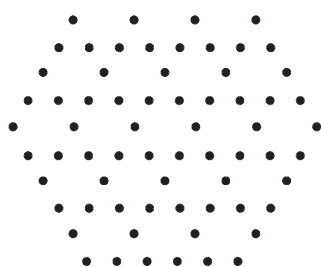


Figure 2

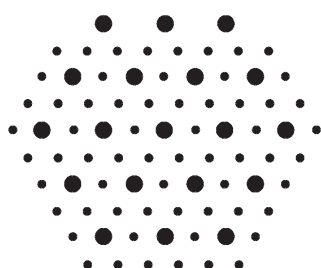
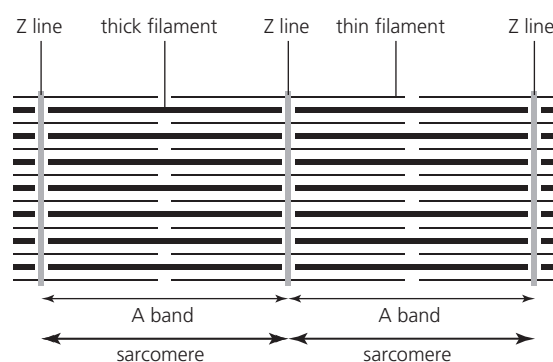


Figure 3

- c Describe the role of calcium ions in the contraction of a sarcomere. [4]

- 2 The figure shows part of a myofibril from skeletal muscle.



- a Describe **two** features, visible in the diagram, which show that the myofibril is contracted. [2]
- b Explain the role of ATP in bringing about contraction of a muscle fibre. [2]
- 3 Explain the relationship to a muscle of: [1]
- a a muscle fibre [1]
- b a myofibril [1]
- c a myosin filament. [1]
- 4 Explain how a muscle fibre contracts. [7]
- 5 Outline the role of the protein titin and antagonistic muscles in muscle relaxation. [5]

B4.1 Adaptation to environment

Paper 1

- 1 Over time, the hull of a sunken ship may become colonized by a wide range of marine organisms. What term is used to describe all of the organisms living in and on a sunken ship?

A A community
B An ecological niche
C A population
D An ecosystem

Standard Level Paper 1, Time Zone 1, May 21, Q20

- 2 What is the ecological term for a group of the same type of organism living together in one area?

A Community
B Domain
C Ecosystem
D Population

- 3 In 1789 Gilbert White, a naturalist, observed eight breeding pairs of swifts (*Apus apus*) in the English village of Selborne. On average, each pair of swifts produces two offspring per year. This would allow the population to rise to 1030 swifts over 200 years. A bird survey carried out in 1983 revealed only 12 breeding pairs in this village.

What could have prevented the numbers rising to 1030?

- I The number of nesting sites remained the same
II The food supply of the swifts remained constant
III Predatory birds in the area were exterminated

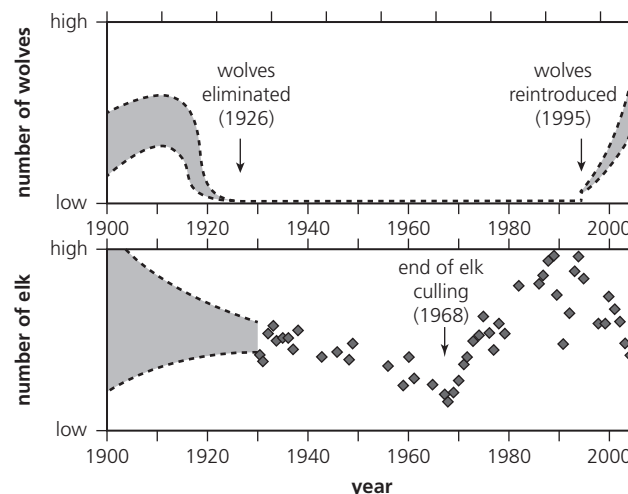
A I only
B I and II only
C II and III only
D I, II and III

Standard Level Paper 1, Time Zone 0, November 18, Q19

Paper 2

- 1 The elimination of wolves (*Canis lupus*) from Yellowstone National Park in 1926 and their reintroduction in 1995 provided the opportunity to examine ecological interactions with elk (*Cervus elaphus*). The National Park Service made efforts between the 1920s and 1968 to reduce the size of elk herds by culling (selective killing) because of concerns about overgrazing.

The graphs provide the trends for the numbers of wolves and elk in Yellowstone National Park from 1900 to 2004.

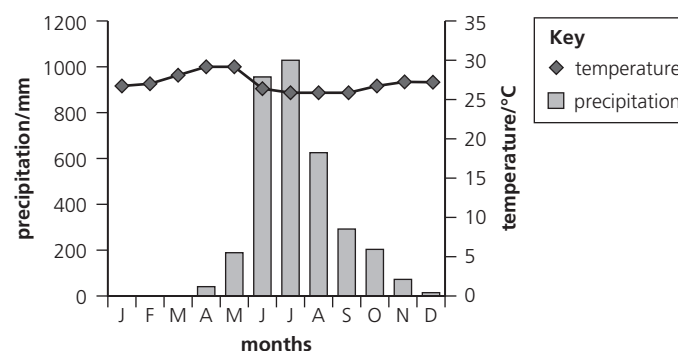


- a Outline the changes in elk population between the years 1930 and 2004. [3]

- b List **two** biotic factors, other than wolf predation or culling, that could affect the elk population. [2]

Higher Level Paper 3, Time Zone 0, November 20, Q18a–b

- 2 The climograph shows data collected at Mangalore, India. The natural vegetation of the surrounding area is forest and the climate is tropical.



- a i Using the climograph, calculate the range of temperature. [1]

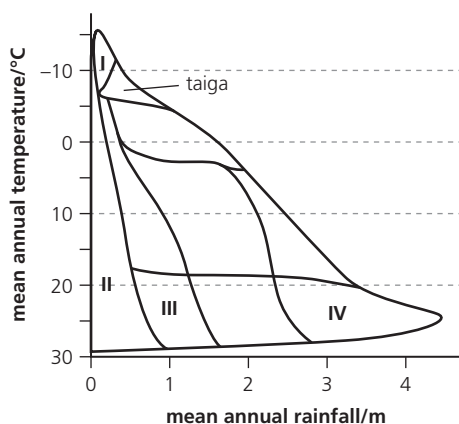
- ii Using the climograph, identify the relationship between maximum temperature and rainfall. [1]

- iii Using the climograph, outline the pattern of rainfall. [1]

- b Natural forests in the area around Mangalore contain hardwood trees such as teak (*Tectona grandis*), which are deciduous, shedding their leaves once a year. Suggest, with a reason, when this might happen. [2]

Higher Level Paper 3, Time Zone 2, May 19, Q15ai–b

- 3 Outline the conditions required for coral reef formation. [4]
- 4 The climograph shows the distribution of biomes according to the temperature and rainfall of land areas on Earth.



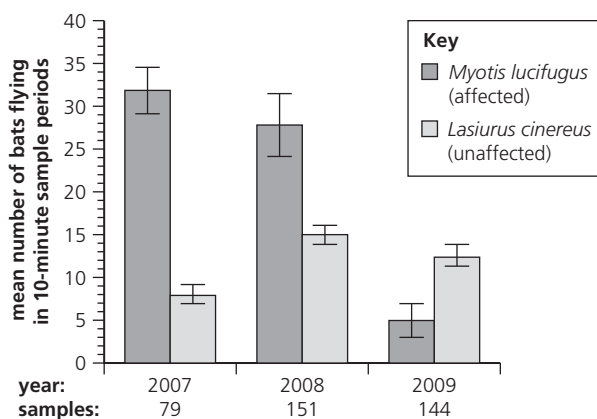
- a Identify the ecosystem with the appropriate numeral from the climograph. [2]

Ecosystem	Numeral
tropical rainforest	
desert	
tundra	

- b Referring to the climograph, explain reasons that the nutrient store in the litter layer of the taiga is greater than in the tropical rainforest. [3]

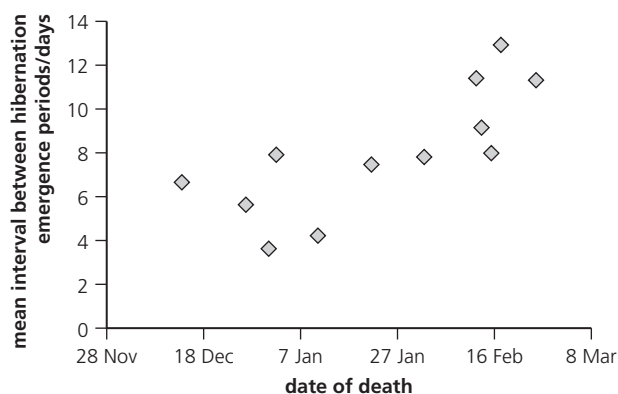
Standard Level Paper 3, Time Zone 0, November 16, Q12a–b

- 5 White-nose syndrome (WNS) is a disease caused by the fungus *Geomyces destructans*. This kills bats from many species during their winter hibernation. Scientists used echolocation to record the number of bat flights over a station in 10-minute sample periods during the summers of 2007 to 2009. The graph shows the mean number of flights and number of recording samples for little brown bats (*Myotis lucifugus*), a species affected by the fungus, along with those of hoary bats (*Lasiurus cinereus*), which are not affected.



- a Calculate the total number of *M. lucifugus* flights that were recorded in the summer of 2007. [1]
- b Suggest **one** limitation of this recording method in determining the accurate mean number of individual bats flying. [1]
- c i Calculate the percentage decline in the mean number of *M. lucifugus* flights for 2009 when compared to 2008. [1]
- ii Evaluate the conclusion that the decline in the population of *M. lucifugus* is due to infection by the fungus. [2]

The graph shows data from a small group of infected bats that died during hibernation. The average time interval between hibernation emergence periods and the date of death were recorded using temperature sensors for these bats.



- d Outline the relationship between date of death and the mean interval between hibernation emergence periods. [1]
- e Discuss whether the data in the graph show that there is a causal link between the date of death and the interval between hibernation emergence periods. [2]
- f Suggest **one** reason, other than the interval between hibernation emergence periods, for some infected bats surviving longer than others. [1]
- g Using all of the data, predict the effect of WNS on bat populations. [3]

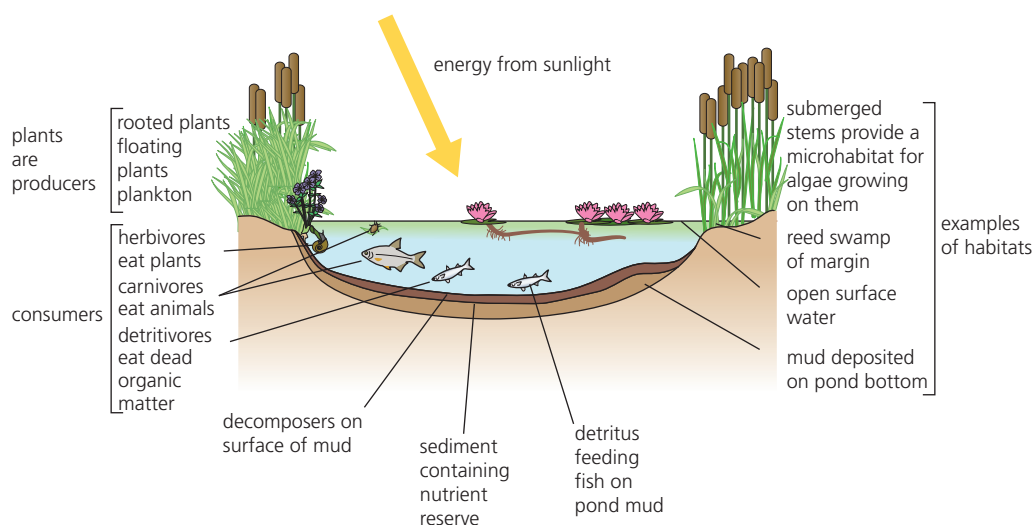
Higher Level Paper 2, Time Zone 1, May 18, Q1a–c, f–i

- 6 Outline adaptations to life in hot deserts and tropical rainforest. [5]
- 7 Explain how abiotic factors can affect the distribution of species in an ecosystem. [6]

Standard Level Paper 3, Time Zone 1, May 18, Q15 (modified)

- 8 The orchid mantis, a predatory insect that lives in the tropical rainforests of South East Asia, has an adult form that resembles an orchid flower. Suggest how this insect may have evolved. [7]

- 9 The figure below represents a transect through a freshwater ecosystem. Notice that a range of habitats within the ecosystem are identified, and that the feeding relationships of the community of different organisms are highlighted.



Determine which of the terms shown below describe each of the listed features of a freshwater lake (one or more terms may fit each feature).

	population	ecosystem	habitat	abiotic factor	community	biomass
a	The whole lake					[1]
b	All the frogs of the lake					[1]
c	The flow of water through the lake					[1]
d	All the plants and animals present					[1]
e	The total mass of vegetation growing in the lake					[1]
f	The mud of the lake					[1]
g	The temperature variations in the lake					[1]

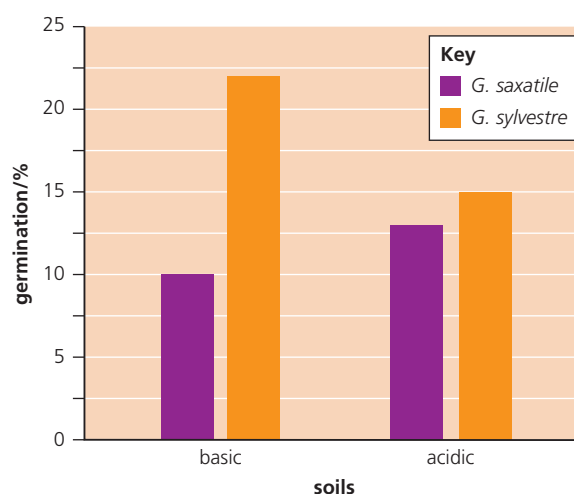
B4.2 Ecological niches

Paper 1

- 1 Which organism would be classified as a saprotroph?
 - A A single-celled eukaryote that obtains organic molecules by photosynthesis and ingestion of other single-celled organisms
 - B An anemone that uses the stinging cells in its tentacles to paralyse its prey, which is passed to an internal gastric cavity through a single opening
 - C A fungus that feeds by secretion of digestive enzymes onto its food and absorption of digested material
 - D A dung beetle that feeds on the faeces of other animals
- 2 Hummingbirds eat flower nectar and small insects. To which nutritional group do they belong?
 - A Autotrophs
 - B Heterotrophs
 - C Mixotrophs
 - D Saprotrophs
- 3 Which organism can be described as an autotroph?
 - I A fungus that digests its food externally and absorbs the products of digestion
 - II A single-celled eukaryote that is able to photosynthesize
 - III A koala bear that feeds by ingesting leaves from an acacia tree
 - A I only
 - B II only
 - C I and II
 - D I and III

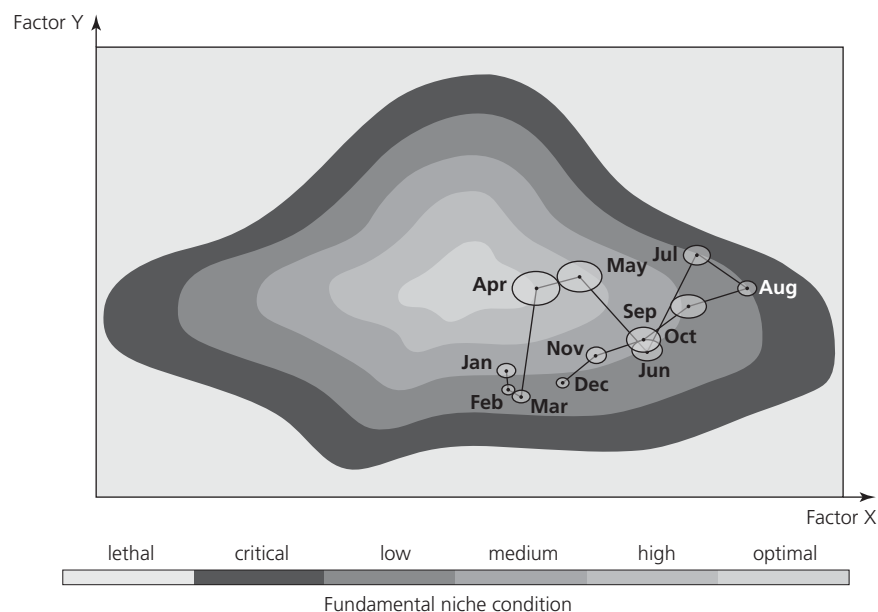
- 4 *Galium* (bedstraw) is a matt-forming herb, found on grassland, moors, heaths and woods. Ecologists have noticed that two species, *Galium saxatile* and *G. sylvestre*, do not grow together. *G. saxatile* is found on acidic peat soils and *G. sylvestre* on limestone soils.

An experiment is carried out to investigate the fundamental and realized niches of these species. Seeds are taken of both species and planted separately in boxes containing both types of soil. The figure below shows the results of the experiment.



- a Describe the results of this experiment. [2]
- b Suggest a reason for the results, and what they indicate about the fundamental and realized niches of both species. [3]

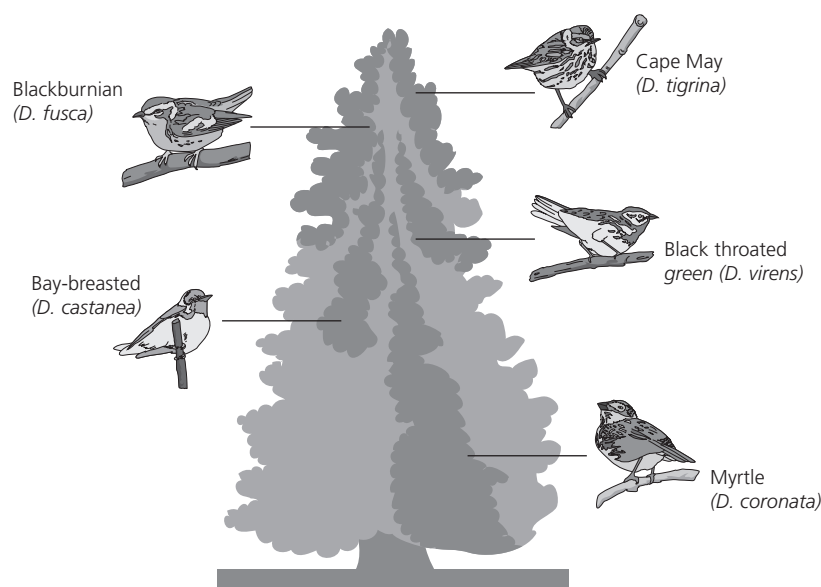
- 5 The model describes the fundamental and realized niches of a species of microscopic marine arthropod in the Northern hemisphere with respect to two different factors (X and Y). The abundance of the species is shown over 12 months. The fundamental niche is separated into five zones ranging from critical to optimal conditions. The population of the species in its realized niche each month is represented by an oval. The size of each oval shows the population abundance.



- Distinguish between fundamental niche and realized niche. [1]
- State the month where the population reaches its maximum. [1]
- Outline how factor Y affects the species from January to April. [2]
 - Suggest, with a reason, what factor Y could be. [2]

Higher Level Paper 3, Time Zone 2, May 18, Q16a–c

- 6 Ecologists studied the distribution of five species of insectivorous wood warblers of the genus *Dendroica* living on different parts of coniferous trees in mature forests.



- Outline the principle of competitive exclusion. [2]
- Other than position in the tree, suggest **two** ways in which the niches of the warblers in the ecosystem may differ. [2]
- The diagram shows the realized niches of the five species of warbler. Suggest how the fundamental niche of *D. castanea* might differ from its realized niche. [2]

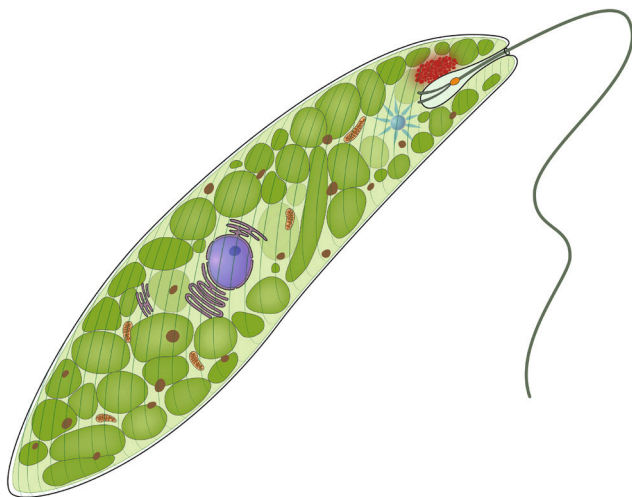
Standard Level Paper 3, Time Zone 0, November 20, Q12a–d

Paper 2

- 1 a Compare and contrast the mode of nutrition of detritivores and decomposers. [2]

	Detritivores	Decomposers
Similarity		
Difference		

- b *Euglena* (see diagram) is a well-known freshwater example of a protist that uses mixotrophic nutrition. Explain the mode of nutrition in *Euglena*. [3]



- 2 Distinguish between obligate anaerobes, facultative anaerobes and obligate aerobes. [5]
- 3 Outline the diversity of nutrition in Archaea. [3]
- 4 Adaptations enable organisms to survive in their environment. Outline the range of adaptations for the following:
- a plants for harvesting light [2]
 - b herbivores for feeding on plants and of plants for resisting herbivory [3]
 - c predators for finding, catching and killing prey and of prey animals for resisting predation. [4]
- 5 Explain the relationship between dentition and the diet of omnivorous and herbivorous representative members of the family Hominidae. [7]
- 6 Using examples, explain why knowledge of the ecological niche of a species is important for its conservation. [7]

C1.1 Enzymes and metabolism

Paper 1

- 1 Which of the following statements does anabolic reactions include?
 - A Hydrolysis of macromolecules into monomers in digestion
 - B The formation of lactic acid in anaerobic respiration
 - C Oxidation of substrates in respiration
 - D Formation of macromolecules from monomers by condensation
- 2 What is meant by the term *induced-fit binding*?
 - A Substrate and active site are complementary in shape
 - B Both substrate and enzymes change shape when binding occurs
 - C Enzymes bind to a specific substrate
 - D Enzymes can be immobilized
- 3 What is the effect of enzymes on activation energy?
 - A Lower the amount of energy required to activate the reacting molecules
 - B Increase the amount of energy required to activate the reacting molecules
 - C Change the shape of the active site
 - D Provide a stable reaction pathway

- 4 The rate of hydrolysis of fish proteins using the enzymes papain and pancreatin was monitored using the apparatus shown (Figure 1). The pH decreased with the progress of hydrolysis, so alkali in the burette was added as necessary in order for the hydrolysis to proceed at constant pH. The rate of protein hydrolysis was measured as the amount of alkali added. Measurements were taken at constant conditions of temperature and pH for two enzyme concentrations, 1% and 0.1% (Figure 2).

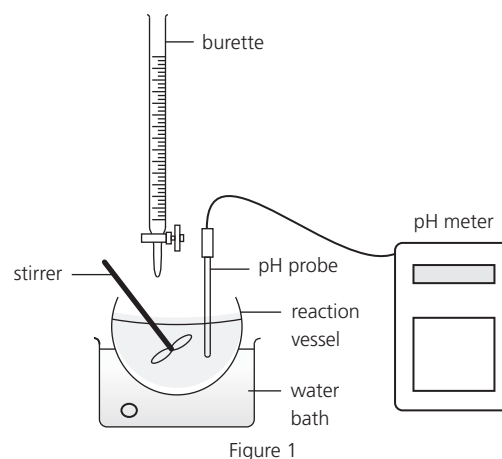


Figure 1

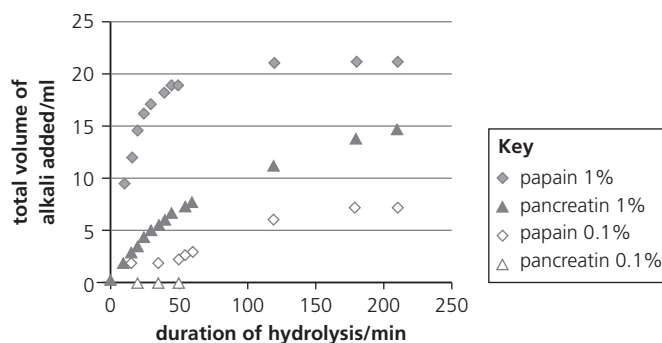


Figure 2

- a State the effect of enzyme concentration on the hydrolysis of proteins. [1]
- b Sketch on a copy of the graph the curve expected if the hydrolysis were performed using papain 0.5 %. [1]
- c Explain what would happen to fish protein hydrolysis if no alkali were added to the reaction vessel. [3]

Higher Level Paper 3, Time Zone 0, November 16, Q1a–c

(Questions 5–7 HL only)

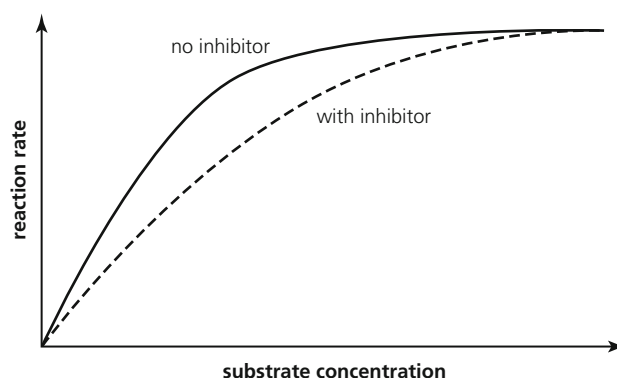
- 5 Which of the following are examples of extracellular enzyme-catalysed reactions?
- I Glycolysis
 - II The Krebs cycle
 - III Chemical digestion in the gut
- A I only
B I and II
C I, II and III
D III only
- 6 Which of the following is an example of feedback inhibition?
- A Change to transpeptidases that confers resistance to penicillin
B The metabolic pathway that produces isoleucine
C The use of statins to control HDLs
D Metabolic processes of the Calvin cycle
- 7 Why is heat generation in metabolic reactions inevitable?
- A Energy transfers are not 100% efficient
B Energy can neither be created nor destroyed
C Energy transfers are exothermic
D Most animals are warm blooded

Paper 2

- 1 Some enzymes function optimally in acidic conditions, while other enzymes function optimally in alkaline or neutral conditions. Explain why different enzymes have different optimal pH values, relating your answer to the structure of the active site. [4]

(Questions 2–5 HL only)

- 2 The sketch shows the relationship between the reaction rate and substrate concentration in the presence and the absence of a competitive inhibitor. Explain the effect of the competitive inhibitor on the reaction rate. [2]



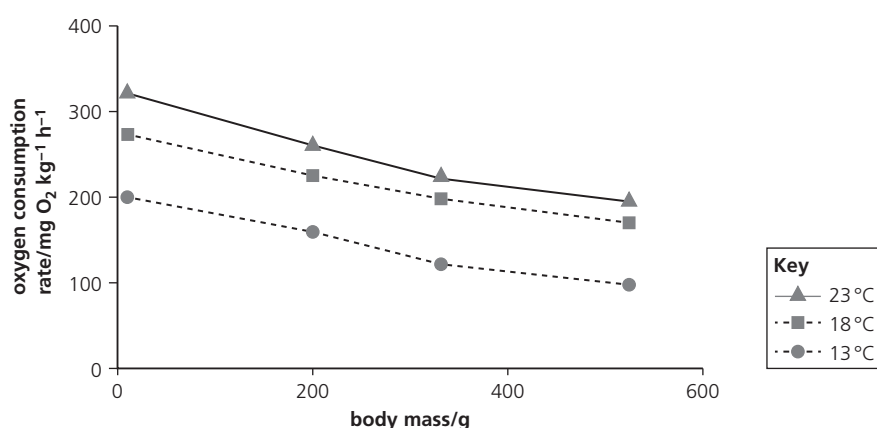
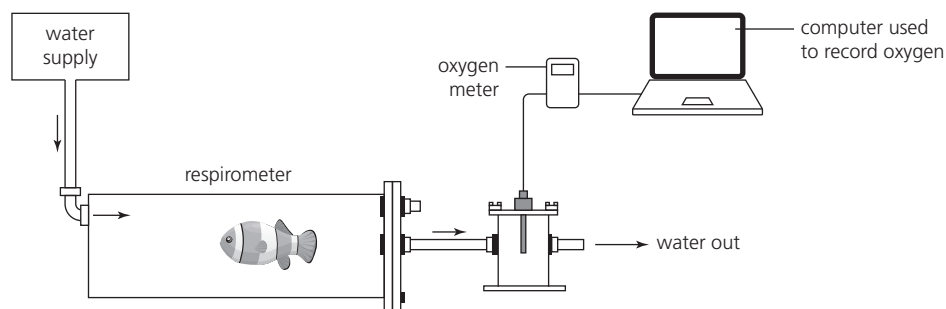
Higher Level Paper 2, Time Zone 2, May 17, Q2a

- 3 Outline the importance of enzymes to metabolic processes. [4]
Higher Level Paper 2, Time Zone 0, November 16, Q3b
- 4 Outline the control of metabolism by end-product inhibition. [5]
Higher Level Paper 2, Time Zone 1, May 19, Q5b
- 5 Explain how the structure of proteins determines their function and optimal operating conditions. [9]

C1.2 Cell respiration

Paper 1

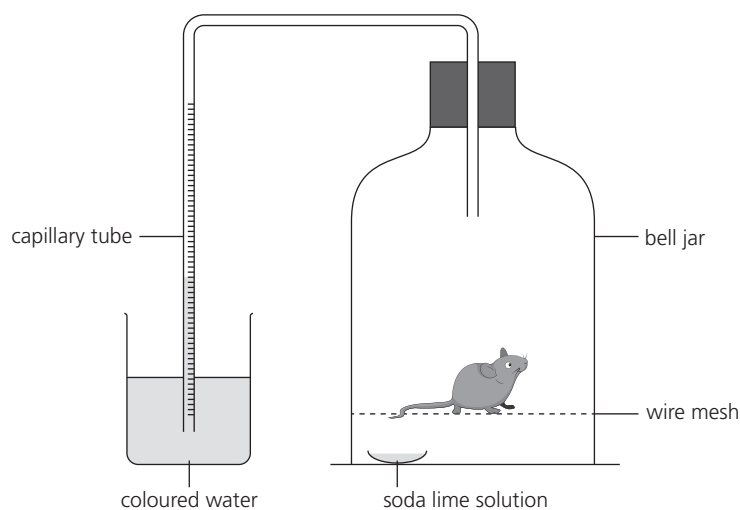
- 1 Which of the following occurs when ATP is converted into ADP?
 - I Energy is stored
 - II Energy is released
 - III Condensation reactions
 - IV Hydrolysis reactions
 - A I only
 - B I and II
 - C II and IV
 - D I and IV
- 2 Which is an ethical concern to consider when doing experiments using a respirometer to measure respiration rate?
 - A Avoid contact with soda lime
 - B Ensure sufficient carbon dioxide concentration
 - C Do not use glassware
 - D Do not seal the manometer
- 3 Which of the following processes require ATP?
 - I Active transport across membranes
 - II Anabolism
 - III Catabolism
 - IV Movement of chromosomes
 - A I and II
 - B I, II and III
 - C I, II and IV
 - D I and IV
- 4 What is the difference between anaerobic and aerobic cell respiration in humans?
 - A Anaerobic respiration releases more energy
 - B Aerobic respiration requires oxygen but anaerobic does not
 - C Aerobic respiration occurs in the cytoplasm and anaerobic respiration in mitochondria
 - D Aerobic respiration uses glucose as a substrate and anaerobic respiration uses fatty acids
- 5 The oxygen consumption rate of the fish *Oplegnathus insignis* was examined in a respirometer at three different water temperatures and at four different body masses.



- a Suggest how the oxygen consumption rate is determined using this apparatus. [2]
- b State the relationship between body mass and the oxygen consumption of fish. [1]
- c Predict the effects of global warming on aerobic respiration in fish. [2]

Standard Level Paper 3, Time Zone 2, May 17, Q1a–c

- 6 In an experiment measuring oxygen consumption, a laboratory mouse was placed in a respirometer for a short time. Soda lime solution absorbed any carbon dioxide produced during the experiment.



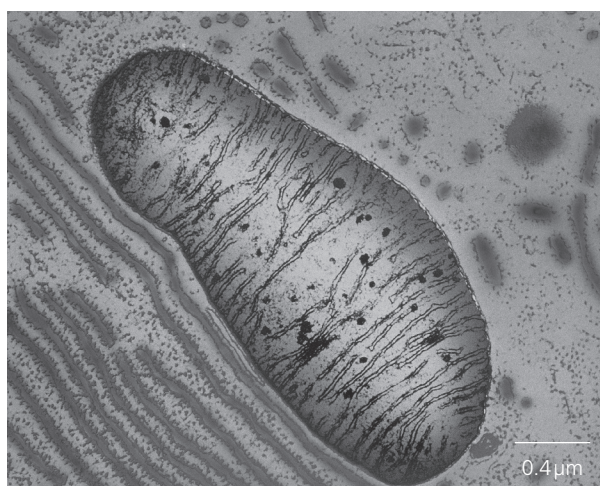
- a Suggest the purpose of the wire mesh. [1]
b Describe how the apparatus measures the oxygen consumption of the mouse. [3]
c Discuss whether the apparatus would be suitable for measuring the oxygen consumption of a small green plant during respiration. [3]

Standard Level Paper 3, Time Zone 0, November 16, Q1a–c

(Questions 7–10 HL only)

- 7 In which part of the cell does glycolysis take place?
A Cytoplasm
B RER
C Mitochondria
D Nucleus
- 8 Which of the following is a role of the electron transport chain?
A Generate an electron gradient
B Generate a proton gradient
C Transport oxygen to a terminal acceptor
D Transport NAD^+
- 9 What is the conversion of pyruvate to lactate a means of?
A Continuing aerobic respiration
B Regenerating NAD in anaerobic cell respiration
C Providing substrates for the link reaction
D Transferring energy by reduced NAD to the electron transport chain

- 10 The TEM shows part of a human pancreas cell including a mitochondrion.



- a Draw an annotated diagram of the mitochondrion. [3]
- b Calculate the magnification of the image. [1]
- c i List the molecules that are taken into the mitochondria for the metabolic pathway of aerobic respiration. [2]
- ii Suggest how these molecules move into the mitochondria. [1]
- d Outline how ATP is generated in mitochondria by chemiosmosis. [5]

Paper 2

- 1 Outline the role of ATP in cells. [3]
- 2 Distinguish between anaerobic and aerobic cell respiration in humans. [5]
- 3 Describe an experiment to investigate the effect of a named variable on the rate of cell respiration in an organism. [7]
- 4 Explain how cell respiration affects each level of biological organization. [9]

(Questions 5–8 HL only)

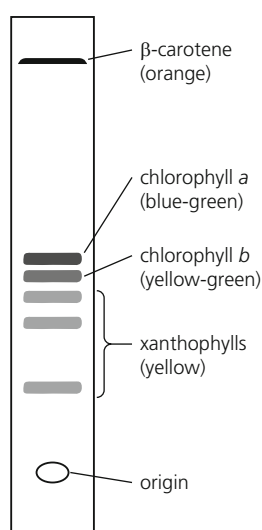
- 5 With reference to cellular respiration, distinguish between the cytoplasm and mitochondria in terms of ATP production, use of oxygen and release of CO_2 . [3]
Explain the stages of aerobic respiration that occur in the mitochondria of eukaryotes. [8]
Higher Level Paper 2, Time Zone 2, May 18, Q6a
- 7 Oxygen is needed to complete aerobic cell respiration. Explain how chemical energy for use in the cell is generated by electron transport and chemiosmosis. [8]
Higher Level Paper 2, Time Zone 1, May 17, Q5a
- 8 Explain the relationship between the structure of a mitochondrion and its function. [9]

C1.3 Photosynthesis

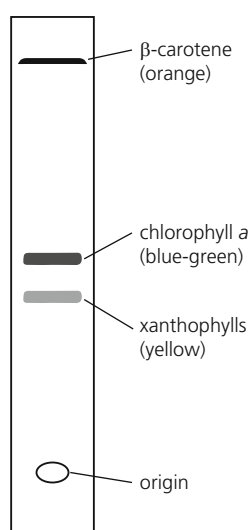
Paper 1

- Which of the following describes how the hydrogen used in photosynthesis to convert carbon dioxide to glucose is obtained?
 - Condensation reactions
 - Splitting water molecules
 - Catabolic metabolic pathways
 - Metabolism of triglycerides
- Which of the following is a limiting factor that affects the rate of photosynthesis?
 - Temperature
 - Oxygen concentration
 - Carbon dioxide concentration
 - I and II
 - I, II and III
 - I and III
 - II and III
- Which technique can be used to separate and identify photosynthetic pigments?
 - Centrifugation
 - Gel electrophoresis
 - Spectrophotometry
 - Chromatography
- Chromatography is a technique used to separate the components of a mixture. The photosynthetic pigments from three organisms were separated by thin layer chromatography: spinach (*Spinacia oleracea*), a red alga (*Porphyra*) and a brown alga (*Fucus*).

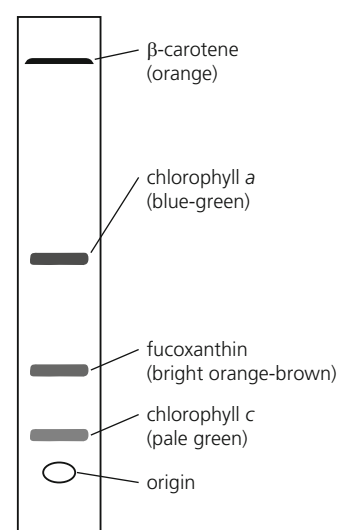
Spinacia oleracea



Porphyra



Fucus



- Identify a pigment found in all three organisms. [1]
- Compare and contrast absorption spectra and action spectra. [2]
- Porphyra* also contains phycoerythrin, which is a red pigment.
 - Suggest a reason for phycoerythrin being absent from the *Porphyra* chromatogram. [1]
 - Predict one colour of light that will be absorbed efficiently by phycoerythrin. [1]

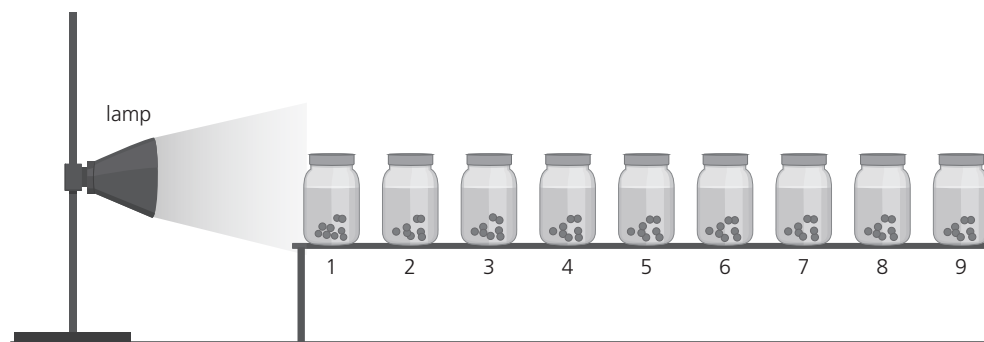
Standard Level Paper 3, Time Zone 2, May 18, Q1a–c

(Questions 5–7 HL only)

- Which are the products of the light-dependent reaction?
 - Reduced NAD and ATP
 - Reduced NADP and ATP
 - Glucose and oxygen
 - Glucose and ATP
- Where does the light-independent reaction take place in the chloroplast?
 - The stroma
 - The intermembrane space of thylakoids
 - Between the outer and inner membranes
 - The grana

- 7 Sodium alginate beads were prepared containing a suspension of *Chlorella* algae. These beads were placed in nine small jars containing hydrogen carbonate indicator solution. Hydrogen carbonate indicator is commonly used to detect changes in pH. The jars were placed at different distances from a lamp, which was the only light source. The distances ranged from 40 to 130 centimetres. Jars were placed one at a time to avoid the jars from shading each other. Colour changes were observed.

← increasing CO ₂ in indicator				atmospheric CO ₂ level				decreasing CO ₂ in indicator →	
yellow		orange		red		magenta		purple	
pH 7.6	pH 7.8	pH 8.0	pH 8.2	pH 8.4	pH 8.6	pH 8.8	pH 9.0	pH 9.2	



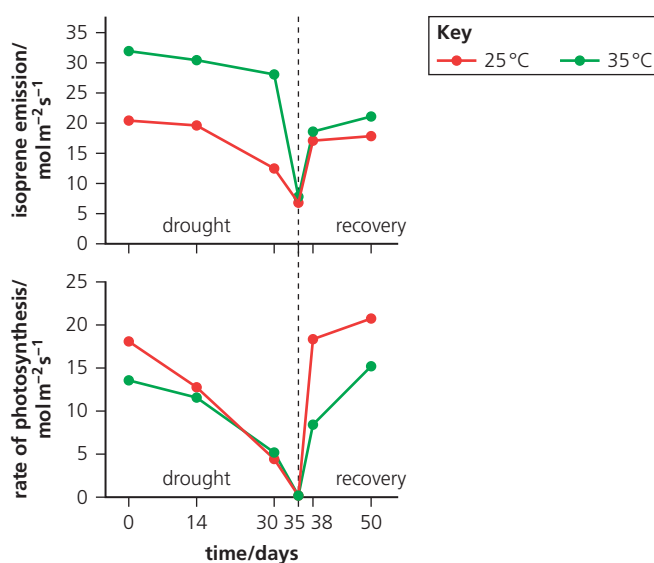
- State the name of the process which occurs in the chloroplasts of *Chlorella* that uses CO₂. [1]
- The colours of the indicator in the jars ranged from yellow to purple after five hours. Predict the distribution of indicator colours in jars 1 to 9. [1]
- Explain the scientific reasoning for your hypothesis. [3]
- Suggest one other factor that has to be kept constant in all the jars during the experiment. [1]

Higher Level Paper 3, Time Zone 0, November 20, Q3a–bii

Paper 2

- 1 Isoprene is a chemical synthesized and emitted in large amounts by some plant species, especially oak (*Quercus* sp.) and poplar (*Populus* sp.) trees. It has been suggested that isoprene increases the tolerance of plants to high temperatures, which can cause a decrease in photosynthesis rates.

Black poplar (*Populus nigra*) plants were subjected to two raised temperatures and to drought. Measurements of photosynthesis and isoprene emission were made during a 35-day-long drought stress (drought period) and 3 and 15 days after re-watering stressed plants (recovery period). The rate of photosynthesis was recorded as the carbon dioxide taken up per unit of leaf per second.



- Suggest one method other than measuring CO_2 uptake by which the rate of photosynthesis could have been measured in these experiments. [1]
- Suggest why heat treatment may reduce photosynthesis rates. [2]
- Outline the effect of drought and re-watering on the rate of photosynthesis. [1]
- Describe the isoprene emissions during the drought and recovery periods at 25°C. [2]
- Compare the effect of the two temperatures on the emission of isoprene. [2]

Higher Level Paper 4, Time Zone 1, May 13, Q1a–e

- Distinguish between action and absorption spectra. [4]
- Describe how photosynthetic pigments can be separated using chromatography and how this is used to calculate R_f values. [5]
- Outline how carbon dioxide-enrichment experiments can be used to predict future rates of photosynthesis and plant growth. [6]
- Explain how controlled experiments can be used to investigate the effect of limiting factors on the rate of photosynthesis. [7]

(Questions 6–11 HL only)

- In cyclic photophosphorylation, predict which of the following occur:
 - photoactivation of photosystem I
 - reduction of NADP^+
 - production of ATP. [1]
 - Draw a diagram of a chloroplast to show its structure as revealed by electron microscopy. Annotate your diagram to indicate the adaptations of the chloroplast to its functions. [3]
 - Explain the role of hydrogen ions used in photosynthesis. [7]
- Higher Level Paper 2, Time Zone 2, May 21, Q6a
- Compare and contrast cell respiration and photosynthesis. [7]
 - Compare and contrast chemiosmosis in mitochondria and chloroplasts. [7]
 - Explain the role of proteins in photosynthesis. [9]

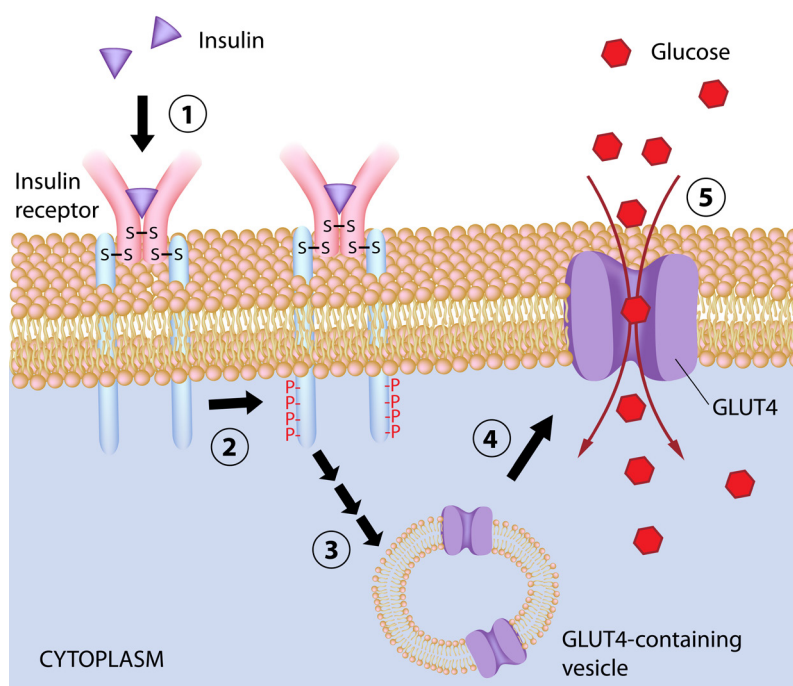
C2.1 Chemical signalling (HL only)

Paper 1 (HL only)

- 1 Which of the following statements about receptors is true?
 - A Receptors are found only on the surface of cells in the plasma membrane
 - B Receptors are specific to the signal ligand
 - C Most receptors can bind many different signal ligands
 - D All receptors can act as channels to regulate movement of substances across the plasma membrane
- 2 What is the name given to the molecule that binds to the particular three-dimensional structure of a receptor site?
 - A Ligand
 - B Scaffold protein
 - C Ion channel
 - D G protein
- 3 Which one of the following is the best description of cell signalling in multicellular organisms?
 - A Intracellular
 - B Intercellular
 - C Both intercellular and intracellular
 - D Neither intercellular or intracellular
- 4 Which one of the following is determined by bacteria using quorum sensing?
 - A Density of the bacterial population
 - B The concentration of nutrients in the surrounding medium
 - C The speed of the surrounding liquid medium
 - D The size of the bacterial population
- 5 Which substance can act as a second messenger?
 - A A kinase
 - B ADP
 - C Cyclic AMP
 - D A peptide hormone
- 6 Hormones such as oestradiol affect female metabolism. How does this hormone act on its target cells?
 - A It activates an enzyme cascade that amplifies the hormone signal
 - B It alters specific receptor sites on the cell surface membrane
 - C It enters the cell and binds to nuclear receptors
 - D It inhibits the synthesis of cholesterol molecules
- 7 Why do many signal transduction pathways use second messengers?
 - A To amplify the message by directly phosphorylating proteins
 - B To induce a signal from the outside to the inside of the cell
 - C To relay the message from the inside of the membrane throughout the cytoplasm
 - D To transport a signal through the lipid bilayer portion of the plasma membrane
- 8 Which of the following is a similarity between G protein-linked receptors and tyrosine kinase receptors?
 - A Activation that results from binding of GTP
 - B Formation of a dimer following binding of a signal molecule
 - C Regions of the receptor that span the plasma membrane
 - D Signal-binding sites specific for steroid hormones
- 9 Which type of cellular response represents a long-term response to an external signal?
 - A Change in enzyme conformation (shape)
 - B Secretion of a hormone into the bloodstream
 - C Phosphorylation of an intracellular protein
 - D Activation of a gene expressing an enzyme
- 10 What are two benefits of having a cascade of cellular events during signal transduction?
 - A Increased amplification of the signal and increased distribution of the signal
 - B Increased amplification of the signal and increased energy consumption
 - C Decreased speed of response and increased energy consumption
 - D Increased specificity and increased targeting of the signal

Paper 2 (HL only)

1 The diagram below shows the effect of insulin on glucose uptake.



- a Suggest, in humans, one type of cell where insulin receptors are mainly found. [1]
 - b Describe the processes 1–4 in the diagram. [4]
 - c Outline the role that insulin plays in cell metabolism. [3]
- 2 Describe the importance of ATP in cell signalling. [3]
 - 3 Suggest **one** advantage and **one** disadvantage of a signalling cascade. [2]
 - 4 Explain the role of kinases in cell signalling. [2]
 - 5 Describe how insulin and glucagon control blood glucose levels. State where these hormones come from, the type of receptors they bind to and how they affect the levels of blood glucose. [6]
 - 6 Compare and contrast the role of hormones and neurotransmitters in chemical signalling. [7]
 - 7 Explain why cell signalling is important for the functioning of organisms. [9]

C2.2 Neural signalling

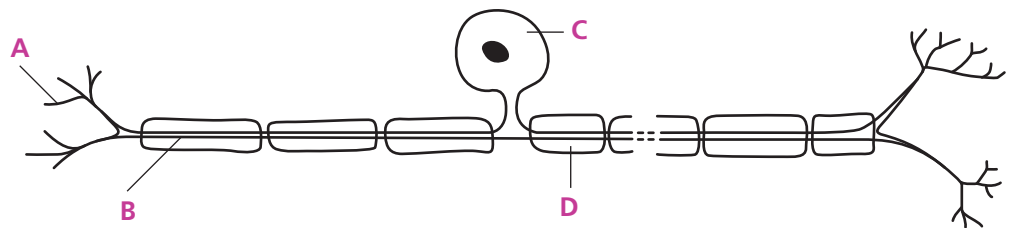
Paper 1

1 Which statement applies to an axon at rest?

- A There is no electric potential difference between the external and internal surfaces of the plasma membrane
- B The external surface of the plasma membrane is positive relative to the internal surface
- C The external surface of the plasma membrane is negative relative to the internal surface
- D The internal surface of the plasma membrane has a much higher concentration of sodium ions

Higher Level Paper 1, Time Zone 1, May 21, Q22

2 The image shows a neuron. Which letter shows the cell body?



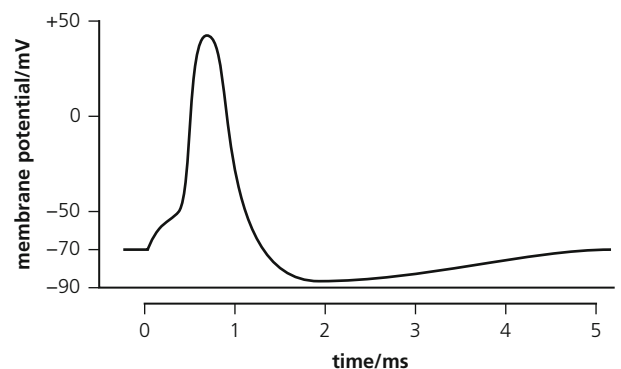
Standard Level Paper 1, Time Zone 0, November 18, Q28 (modified)

3 Neurotransmitters are released into the synaptic cleft from the presynaptic neuron and travel to a receptor on the postsynaptic neuron membrane. Which processes are required for this to happen?

	Release into synaptic cleft	Travel to postsynaptic neuron membrane
A	exocytosis	diffusion
B	active transport	diffusion
C	exocytosis	active transport
D	active transport	active transport

Standard Level Paper 1, Time Zone 1, May 17, Q25

5 The graph shows changes in the membrane potential in an action potential. What is the approximate value of the threshold potential?



- A -89 mV
- B -70 mV
- C -50 mV
- D +47 mV

Standard Level Paper 1, Time Zone 0, November 21, Q28 (modified)

(Questions 4–7 HL only)

4 Which of the following definitions refers to *repolarization*?

- A The return of polarity towards the resting potential following depolarization
- B A temporary and local reversal of the resting potential
- C A period during which a nerve is unresponsive to further stimulation
- D The potential difference produced across the plasma membrane of the nerve cell when stimulated

6 What can oscilloscopes be used to measure?

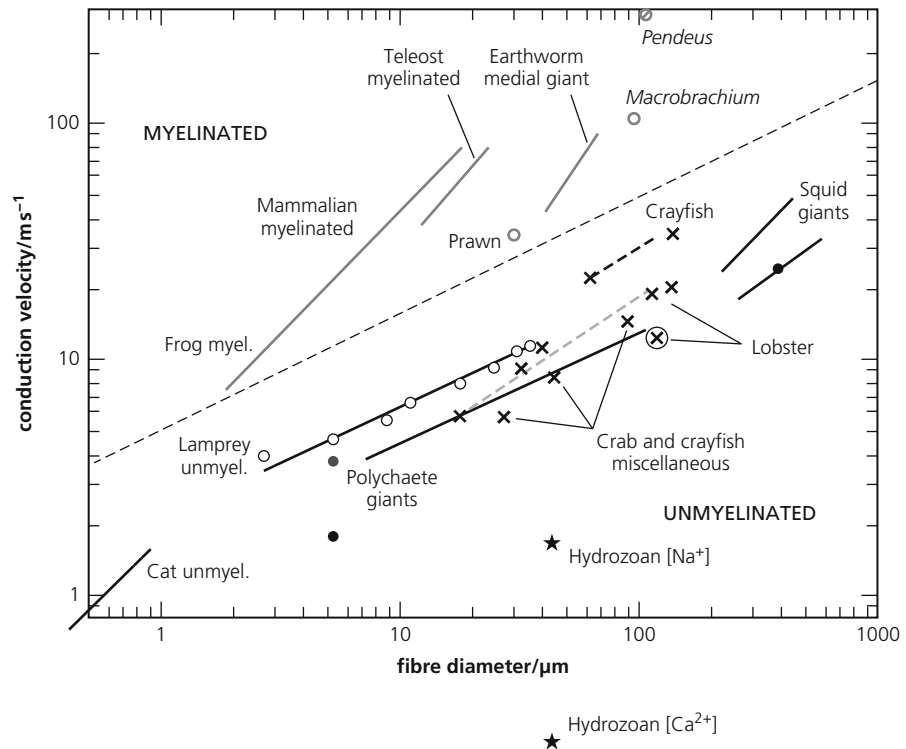
- I Resting potentials
- II Action potentials
- III Number of impulses per second

- A I only
- B I and II
- C I, II and III
- D III only

- 7 How do exogenous chemicals affect synaptic transmission?
- A Causing vesicles to fuse to the presynaptic membrane
 - B Increasing the concentration of cholinesterase
 - C Causing a reduction in the diameter of the synaptic cleft
 - D Blocking reuptake of the neurotransmitter

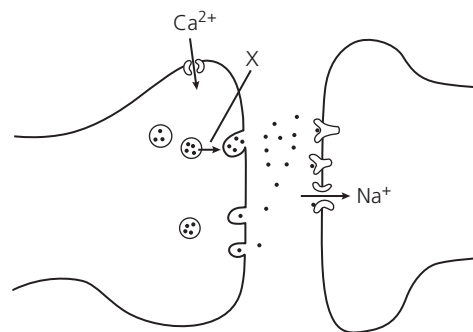
Paper 2

- 1 Analyse the data shown in the figure below, which shows the effect of nerve fibre diameter on conduction velocity for a variety of different animals.



Lines indicate general relations over a range of diameters, many taken from Bullock and Horridge (1965) but adjusted to a standard temperature of 20 °C (Chapman and Pankhurst 1967). Specific labelled points or lines from the following sources: Squid: Hartline & Young 1936 cited in Pumphrey and Young (1938); Earthworm: Eccles, Granit & Young (1932); Penaeus and Macrobrachium: Kusano (1966). Crayfish: Govind and Lang (1976); Hydromedusa: Mackie and Meech (1985).

- a Compare and contrast the speed in myelinated and non-myelinated fibres. [4]
- b Explain the effect of size of axon diameter and myelination on conduction velocity. [7]
- 2 The diagram shows part of two neurons.



- a State the name of the structure shown. [1]
- b X indicates the movement of a structure in the neuron. Explain what events trigger this movement and what happens next. [3]

Standard Level Paper 2, Time Zone 0, November 20, Q3bi-ii

- 3 Outline the way the resting potential allows a nerve cell to be ready for the transmission of a nerve impulse. [4]
- 4 Using a labelled diagram, explain how impulses are transmitted across a synapse. [8]
- 5 Neural signalling requires an understanding of many different topics in biology. Explain how the nervous system transmits signals throughout the body. [9]

(Questions 6–10 HL only)

- 6 Mice (*Mus musculus*) have various defence systems against predators such as foxes (*Vulpus vulpus*) or stoats (*Mustela erminea*). The mice release specific alarm compounds when under threat that serve as danger signals for other mice. Predators also release scents that the mice can detect.

In one study, mice were exposed to paper soaked in compounds taken from other mice, foxes or stoats in a test chamber. The scientists then measured the reaction of three different groups of neurons used in smelling: G1, G2 and G3, as shown in the diagram (Figure 1).

The percentage of G1, G2 and G3 neurons responding to the mouse, fox and stoat compounds, as well as a control compound, are shown in the chart (Figure 2).

The scientists recorded the neural traces (action and resting potentials) of six G1 neurons exposed to the compounds from the different animals. The horizontal bar beneath each trace corresponds to the time of exposure to the test compound (Figure 3).

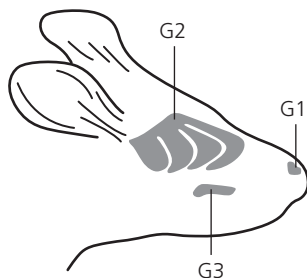


Figure 1

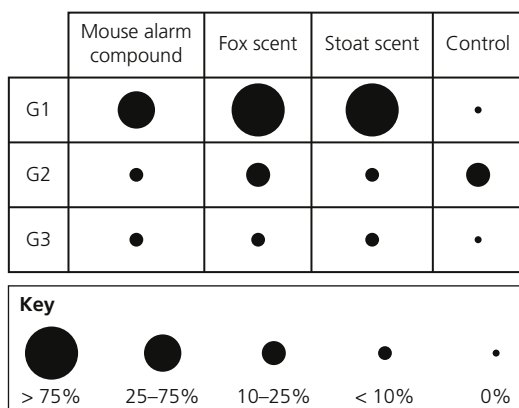


Figure 2

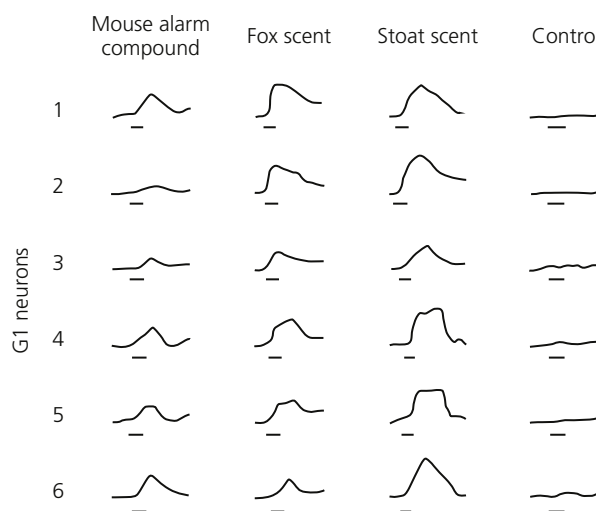


Figure 3

- a State the percentage of G2 neurons in the mice that respond to the fox scent. [1]
 - b Using evidence from the chart, identify, giving a reason, which group of neurons responded most to the chemicals. [1]
 - c State the name of the instrument used to make these neural traces. [1]
 - d Distinguish between the effects of the mouse alarm compound and the effects of the control compound on the G1 neurons. [1]
 - e Compare and contrast the effects of the mouse alarm compound and stoat scent on the G1 neurons. [2]
 - f Deduce whether there is a correlation between the neural traces and the percentage of responding G1 neurons. [2]
- Standard Level Paper 2, Time Zone 2, May 19, Q1 (part)
- 7 a The brain requires a large energy input. Suggest **one** reason for this. [1]
 - b Outline the functional magnetic resonance imaging (fMRI) technique for brain research. [2]
- Higher Level Paper 3, Time Zone 1, May 18, Q5b–c
- 8 Explain the effect of neonicotinoid pesticides on the cholinergic synapses of insects. [5]
 - 9 Outline how cocaine affects the nervous system and why it can lead to addiction. [5]
 - 10 Explain the propagation of electrical impulses along a neuron including the role of myelin. [7]

Standard Level Paper 2, Time Zone 0, May 16, Q5

C3.1 Integration of body systems

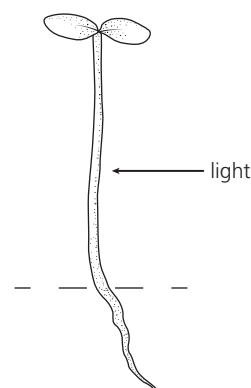
Paper 1

- 1 What is meant by *emergent properties*?
 - A A property which a complex system has but which the individual parts do not have
 - B Knowledge of the individual parts of a system is sufficient to understand or predict overall system behaviour
 - C The separate activities of the parts of a larger system
 - D The growth of an organ or tissue from an organism
- 2 How can the integration of organs in animal bodies be achieved?
 - I Hormonal signalling
 - II Nervous signalling
 - III Transport of materials and energy
 - A I only
 - B I and II
 - C I, II and III
 - D I and III
- 3 Which of the following does the cerebellum have a role in?
 - A Visual processing
 - B Auditory processing
 - C Coordinating skeletal muscle contraction and balance
 - D Breathing and maintaining heart rate
- 4 What role does epinephrine facilitate?
 - A Intense muscle contraction
 - B Storage of glucose as glycogen
 - C Reabsorption of water in the kidney
 - D Decreased heart rate
- 5 Which hormone regulates the hours of sleep and wakefulness?
 - A Oestradiol
 - B Insulin
 - C Auxin
 - D Melatonin
- 6 Which of the following controls peristalsis in the intestine?
 - A The cerebellum
 - B The central nervous system
 - C The enteric nervous system
 - D The peripheral nervous system

Standard Level Paper 1, Time Zone 0,
November 21, Q29 (modified)

(Questions 7–10 HL only)

- 7 The diagram shows a plant shoot and the direction of the light which the shoot received.



What are the direction of movement and the effect of auxin in the tip of a plant shoot when receiving light from one side?

	Direction of movement of auxin	Effect of auxin on cell elongation
A	towards light	promotes
B	towards light	inhibits
C	away from light	promotes
D	away from light	inhibits

Higher Level Paper 1, Time Zone 1, November 21, Q33

- 8 How does auxin contribute to phototropism?
 - A It increases production of light-sensitive proteins
 - B It increases growth of cells on the shaded side of the stem
 - C It inhibits growth of axillary buds
 - D It inhibits stem elongation

Higher Level Paper 1, Time Zone 2, May 21, Q34

- 9 The image shows seedlings that have been exposed to unidirectional light.



Which statement explains the growth towards the light source?

- A** Light causes auxin to inhibit cell division in the shoot meristem
- B** Light causes auxin to promote cell division in the shoot meristem
- C** Auxin is concentrated in the side of the shoot with light and inhibits cell elongation
- D** Auxin is concentrated in the side of the shoot without light and promotes cell elongation

Higher Level Paper 1, Time Zone 2, May 18, Q30

- 10** Ethylene stimulates the changes in fruits that occur during ripening by the process of:

- A** Negative feedback
- B** Positive feedback
- C** Respiration
- D** Photosynthesis

Paper 2

- 1** Compare and contrast hormonal and nervous communication. [7]

Higher Level Paper 2, Time Zone 1, May 21, Q6c

- 2** Distinguish between conscious and unconscious processes. [3]

- 3** The central nervous system (CNS) gathers sensory information and coordinates activity. Outline how coordination is achieved by:

- a** Input to the spinal cord and cerebral hemispheres of the brain. [3]
- b** Output from the cerebral hemispheres of the brain to muscles. [3]

- 4** Compare and contrast the structure and function of sensory and motor neurons. [6]

- 5** Explain the role of baroreceptors and chemoreceptors in the control of heart rate. [5]

- 6** Using a named species, explain how each level of biological organization (molecules, cells, organism and ecosystem) contributes to the emergent properties of the whole organism. [7]

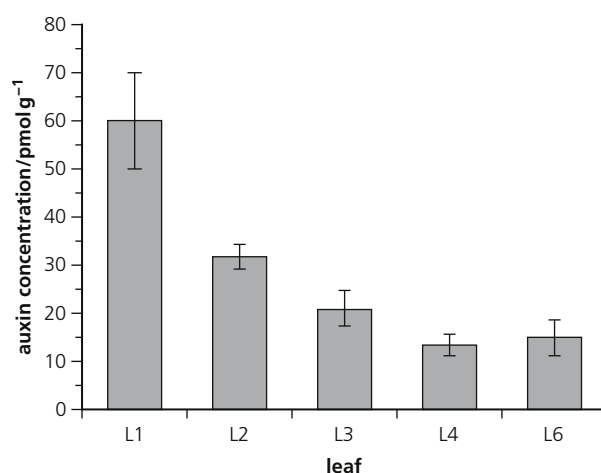
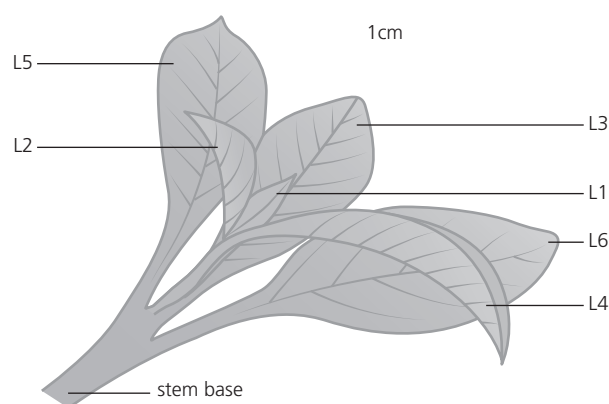
(Questions 7–9 HL only)

- 7** Outline how both qualitative and quantitative data can be used to assess trophic responses in seedlings. [5]

- 8** Auxin can be used to promote the development of roots from stem and leafy cuttings in some plants. In a study into the distribution of auxin in the development of these roots, scientists measured the amount of auxin in different leaves of a shoot tip of *Petunia hybrida*.

The figure indicates the numbering of leaves on the shoot, from L1 as the youngest and smallest to L6 as the largest and oldest leaf. The developmental stage of L5 and L6 was very similar, so L5 was not analysed. The stem base is the lowest part of the cutting where roots may form.

The graph shows the auxin concentration in the different leaves.



- a** Calculate the difference in the concentration of auxin found in L1 and L6. [1]
- b** Identify the relationship between the concentration of auxin and the age of the different leaves. [2]

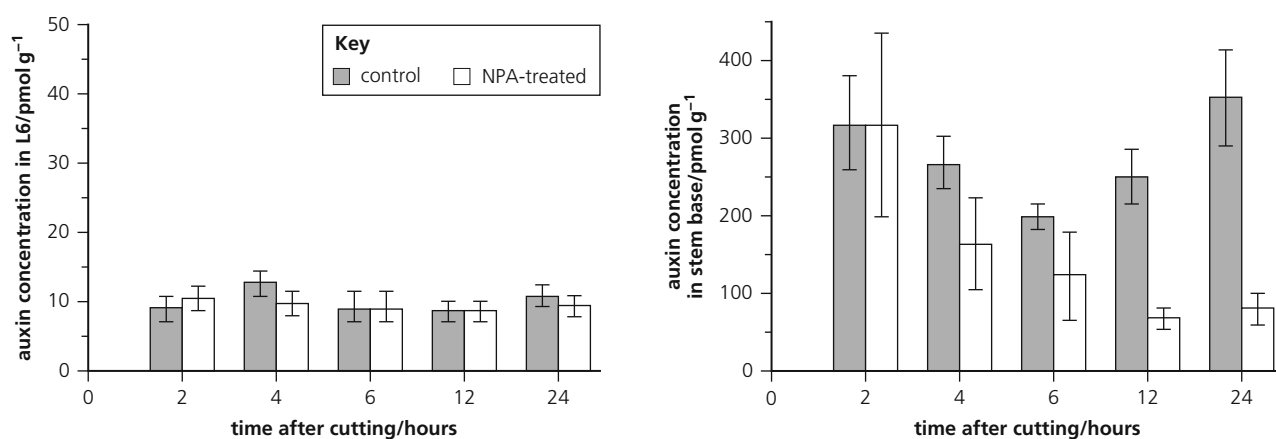
N-1-naphthylphthalamic acid (NPA) is an inhibitor used to block auxin transport. NPA was sprayed onto the leaves of a set of cuttings for 14 days. Development of the roots in control (non-treated) and NPA-treated cuttings was measured 14 days after taking the cuttings.

The table shows the influence of NPA on rooting.

	Mean number of roots per cutting	Mean root length / cm	Mean total root length per cutting / cm
control	53.2	1.4	47.4
NPA-treated	8.0	0.6	1.0

c Analyse the effect of NPA on the formation of roots. [2]

The scientists also measured the changes in auxin concentration in L6 and the stem base during the early period of root formation. They recorded the concentration in the control and NPA-treated cuttings for 24 hours after taking the cuttings.



d i Compare and contrast the changes in auxin concentration in the stem base over time for the control and NPA-treated cuttings. [2]

ii Deduce the effect of NPA on auxin transport between L6 and the stem base. [2]

e Based on all the data presented and your knowledge of auxin, discuss the pattern of auxin production and distribution in the leaves, and the possible relationship to root formation in leafy cuttings of *Petunia hybrida*. [3]

Higher Level Paper 2, Time Zone 2, May 17, Q1a–e

9 Outline how the hormone auxin controls phototropism in plant shoots. [5]

Higher Level Paper 2, Time Zone 1, May 21, Q6b

C3.2 Defence against disease

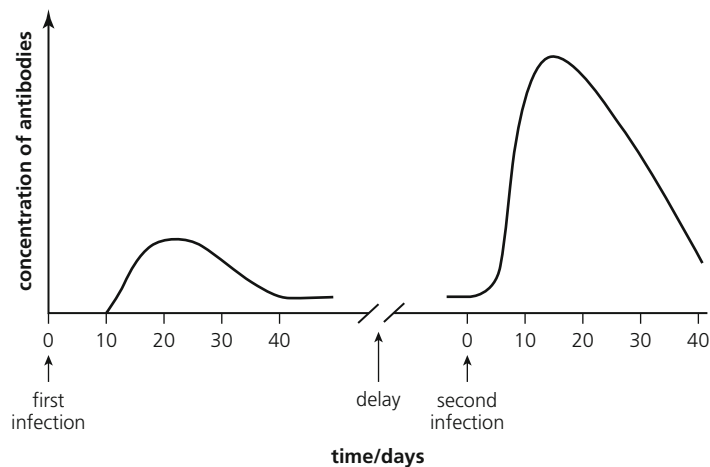
Paper 1

1 What occurs as a result of a cut in the skin of a finger?

- A Prothrombin is transformed into thrombin
- B Fibrin is converted to insoluble fibrinogen
- C Platelets produce antibodies to prevent infection
- D Clotting factors are released from red blood cells

Standard Level Paper 1, Time Zone 0, November 21, Q25

2 A person was infected with a pathogen and then later in life they were reinfected with the same pathogen. The graph shows the concentration of antibodies found in the blood that were produced in response to these two infections.



What is the reason for the faster rise in antibody concentration after the second infection?

- A The patient had previously been vaccinated with the antibody
- B Antibodies had been stored after the first exposure
- C Lymphocytes rapidly reproduced to form plasma cells
- D The second exposure was more infectious

Standard Level Paper 1, Time Zone 0, November 21, Q26

3 Which cells does HIV attack?

- I Lymphocytes
- II Macrophages
- III Platelets
- IV Erythrocytes (red blood cells)

- A I only
- B I and II
- C I, II and III
- D IV only

- 4 What is non-specific immunity to disease?
- A Blocking prokaryotic metabolism with antibiotics
 - B Production of antibodies by lymphocytes
 - C Endocytosis of pathogens by white blood cells
 - D Production of cloned plasma cells

Standard Level Paper 1, Time Zone 0, November 19, Q27

- 5 Why do antibiotics not damage human cells?
- A The antibiotic is only taken for a short time
 - B The antibiotic dose is too small to be harmful to human cells
 - C The antibiotic is broken down by cell metabolism
 - D Human metabolism is different from bacterial metabolism

- 6 Which components of the blood provide specific immunity against infectious diseases?

- A Plasma
- B Memory cells
- C Platelets
- D Phagocytes

- 7 What is a characteristic of antigens?

- A They recognize foreign substances
- B They are produced in bone marrow
- C They cause disease in humans
- D They stimulate the production of antibodies

Standard Level Paper 1, Time Zone 0, November 17, Q26

Paper 2

- 1 Some blood proteins are involved in defence against infectious disease. Explain the roles of named types of blood proteins in different defence mechanisms. [8]

Standard Level Paper 2, Time Zone 2, May 17, Q5c

- 2 Tuberculosis (TB) is an infectious disease caused by the bacterium *Mycobacterium tuberculosis*.

- a Outline the structures in *M. tuberculosis* that are not present in a human cell. [3]
- b Explain the production of antibodies when a patient is infected with the TB bacterium. [7]
- c Describe the risk to the human population of indiscriminate use of antibiotics. [5]

Standard Level Paper 2, Time Zone 2, May 21, Q6a–c

- 3 Describe what is meant by *innate immune response*. [2]

- 4 Outline the immune response that leads to the production of antibodies after a traditional vaccination against a specific viral infection. [3]

- 5 Vaccination has been used successfully to control the spread of many infectious diseases in the population. Explain how vaccination works in terms of immunological memory and herd immunity. [4]

- 6 Explain why antibiotic resistance is an example of evolution by natural selection. [7]

- 7 Describe how careful observations have led to progress in the control of infectious diseases. [6]

C4.1 Populations and communities

Paper 1

- 1 Which level(s) of ecological complexity involve(s) biotic factors but not abiotic factors?
 - I Community
 - II Ecosystem
 - III Population
 - A I only
 - B II only
 - C I and II only
 - D I and III only

Standard Level Paper 1, Time Zone 0, November 20, Q16
- 2 Which is the correct definition for *carrying capacity*?
 - A The number of different species that can be supported by a given environment
 - B The minimum number of a species that can be supported by a given environment
 - C The maximum number of a species that can be supported by a given environment
 - D The total number of individuals of all species in an area
- 3 Which of the following is an example of negative feedback of population size?
 - A Predation returning a prey population to its carrying capacity
 - B An increase in prey leading to a decrease in predators
 - C Density-independent factors
 - D Exponential growth of a population
- 4 Which of the following interspecies interactions is an example of parasitism?
 - A African lion killing a kudu (a savannah herbivore)
 - B A fungus causing the death of the evergreen robber frog
 - C Rhizobium bacteria living in the root nodules of a legume plant
 - D A sheep tick attached to the skin of a cat where it has fed on its blood

- 5 Limpets are molluscs with conical shells that cling tightly to rocks on seashores. In a study of two species of limpets found on rocks along the Oregon coast, 30 randomly placed quadrats were used to determine how often the two species occurred together. The table shows the data that were collected.

	<i>Lottia pelta</i> present	<i>Lottia pelta</i> absent	Total
<i>Lottia scutum</i> present	15	5	20
<i>Lottia scutum</i> absent	5	5	10
Total	20	10	30

Which statistical method will determine whether these two species occur together by chance or by some kind of interaction?

- A Chi-squared test
 - B *t*-test
 - C Standard deviation
 - D Means and ranges

Standard Level Paper 1, Time Zone 0, November 18, Q24
- 6 What is an alien species?
 - A A species that is introduced into an area by human activity
 - B A species with a large geographical distribution
 - C A species unrecognized by science
 - D A pathogenic species
- 7 In an area of forest measuring 100 m by 100 m, samples were taken to estimate the number of silver maple (*Acer saccharinum*) trees in the forest. The number of trees counted in each of five areas of 400 m² was recorded. Approximately how many silver maple trees are in the 10 000 m² area of forest?

	3			
			5	
4		5		
			8	

- A 5
 - B 25
 - C 125
 - D 625

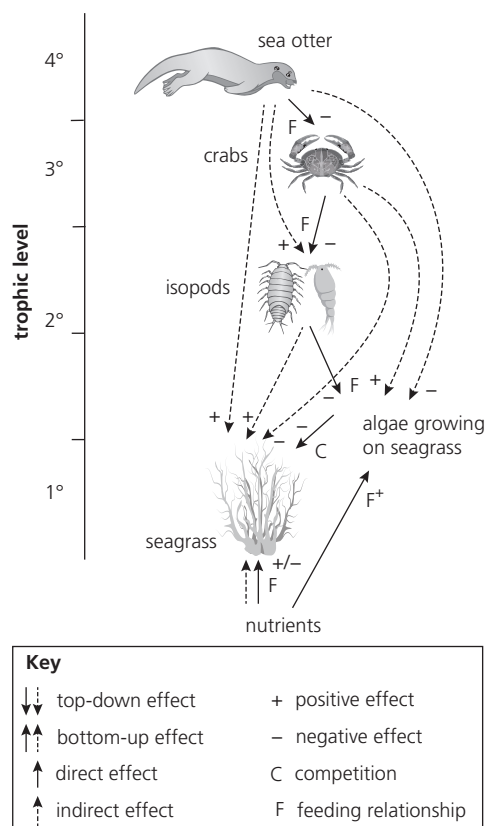
- 8 Damselflies are flying insects that feed on other insects. They live on or near ponds and rivers. An ecologist wants to estimate the size of the damselfly population in a site of special scientific interest.



- a i State the most appropriate method that they should use to estimate the population size. [1]
 ii Outline the method they would use to make this estimate. [4]
 iii Explain the limitations of the method and how they may affect the estimate. [3]
 b Distinguish between ecological methods used to sample sessile species compared to mobile species. [3]

Paper 2

- 1 Distinguish between the interspecific relationships of mutualism, pathogenicity and parasitism, providing an example of each. [3]
 2 The interaction web shows top-down and bottom-up effects in a seagrass study system.



- a Identify which of the types of interaction shown in the key occur between crabs and seagrass. [2]
 b Describe how the sea otter indirectly affects seagrass. [2]
 c Explain how nutrients can have a positive or negative bottom-up effect on seagrass. [3]

Higher Level Paper 3, Time Zone 2, May 18, Q15a–c

- 3 Reef-building corals are formed through a relationship between coral polyps and an algae called *Zooxanthellae*.
 a Describe the exchange of materials between the coral's polyps and *Zooxanthellae*. [2]
 b Outline the relationship between *Zooxanthellae* and coral reef species. [2]
 c Suggest how sea depth may act as a limiting factor for coral growth. [2]
 4 a Explain the factors that can contribute to the exponential growth phase in a sigmoid population curve. [3]
 b Outline the effect of carrying capacity on the growth of a population. [2]

Higher Level Paper 3, Time Zone 2, May 19, Q16a–b

- 5 Explain how the introduction of an invasive species will affect the population size of an endemic species, and the impact this will have on the biodiversity of the ecosystem in which it is found. [9]
 6 Explain, using a range of examples, how models are used in the study of biology. [9]

C4.2 Transfers of energy and matter

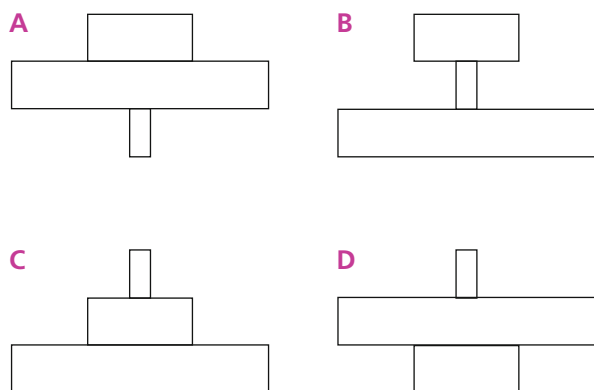
Paper 1

- 1 Which of the following systems is an example of an ecosystem?
- A Open systems
 - B Isolated systems
 - C Closed systems
 - D Deterministic systems

- 2 In a woodland ecosystem, each tree provides food for numerous aphids which feed on the sap of the tree. The aphids are eaten by carnivorous beetles, as shown in the food chain.

oak tree → aphids → beetles

Which pyramid of energy represents this relationship?



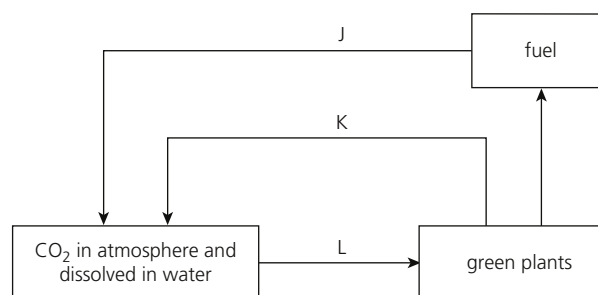
Standard Level Paper 1, Time Zone 0, November 21, Q18

- 3 Which processes occur in an ecosystem?
- I Biomass increases in each successive trophic level
 - II Inorganic nutrients are recycled
 - III Chemical energy is stored in carbon compounds
- A I and II only
 - B I and III only
 - C II and III only
 - D I, II and III

Higher Level Paper 1, Time Zone 2, May 18, Q22

- 4 Which of the following does chemoautotrophic nutrition involve?
- A Use of light as the external energy source
 - B Parasitic relationships
 - C Consuming other organisms
 - D Oxidation reactions as the energy source

- 5 The diagram shows the carbon cycle.



Which two processes correspond to the labelled arrows?

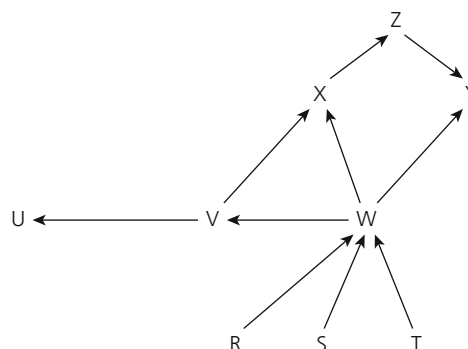
- A K is combustion and L is catabolism
- B J is anabolism and K is respiration
- C J is combustion and K is respiration
- D J is anabolism and L is catabolism

Standard Level Paper 1, Time Zone 0, November 17, Q18

- 6 What restricts the length of a food chain?
- A Energy losses between the trophic levels
 - B A greater biomass at the higher trophic levels
 - C The number of species in the food web
 - D The consumption of waste by detritivores

Standard Level Paper 1, Time Zone 0, November 16, Q18

- 7 The diagram shows the food web for an aquatic ecosystem in which letters R–Z represent individual species.

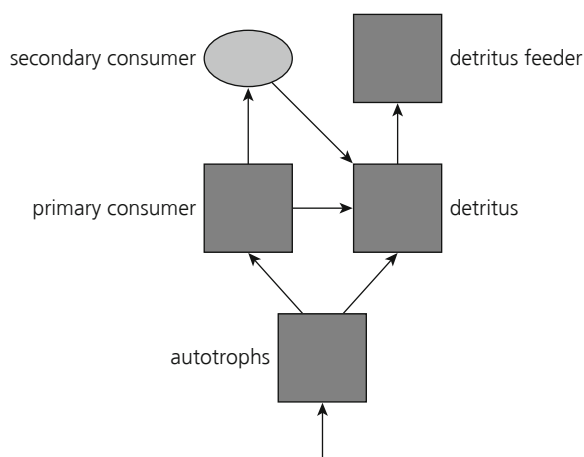


Which organism is a tertiary consumer?

- A Organism T
- B Organism U
- C Organism W
- D Organism Y

Standard Level Paper 1, Time Zone 1, May 19, Q18

- 8 The diagram shows the energy flow between five 'sinks' in a terrestrial ecosystem.



In a typical terrestrial ecosystem, which trophic level would have the highest biomass?

- A Autotrophs
- B Primary consumers
- C Secondary consumers
- D Detritus feeders

Standard Level Paper 1, Time Zone 1, May 21, Q21

- 9 Which statement is true for secondary production?

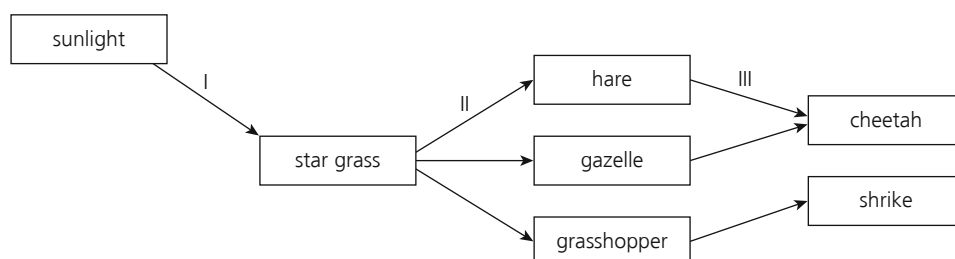
- A It is higher than primary production
- B It is the accumulation of carbon compounds in biomass by autotrophs
- C It is the accumulation of carbon compounds in biomass by heterotrophs
- D It is measured in g m^{-2}

- 10 Plankton are major producers in marine ecosystems. Only a small proportion of the energy harvested by plankton is passed to the primary consumers. Which process in phytoplankton results in the largest loss of energy that could otherwise be utilized by consumers?

- A Reproduction
- B Homeostasis
- C Excretion
- D Respiration

Higher Level Paper 1, Time Zone 0, November 20, Q16

- 11 The diagram shows interactions between food chains in an ecosystem in the African savannah. Which arrows indicate the flow of chemical energy?

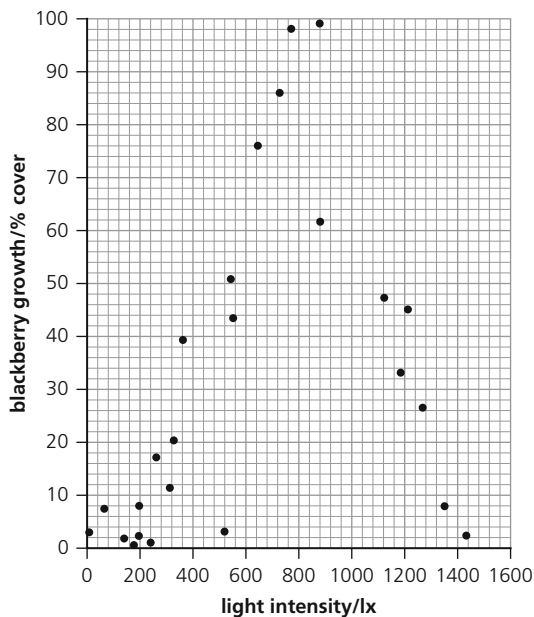


- A I and II only
- B I and III only
- C II and III only
- D I, II and III

Standard Level Paper 1, Time Zone 0, November 18, Q17

■ Paper 2

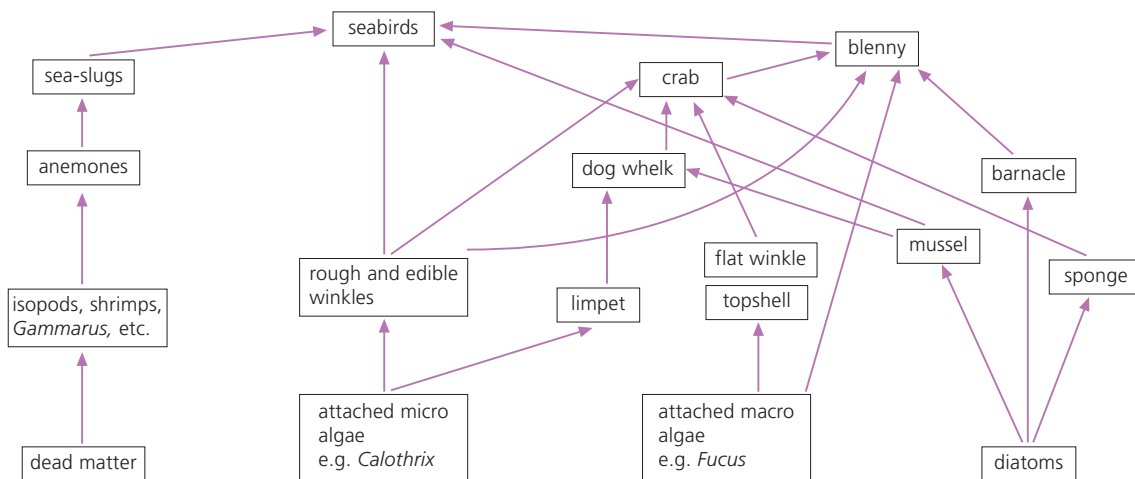
- 1** The blackberry (*Rubus fruticosus*) is a plant that grows in deciduous woodlands in many parts of the world. A 30m transect was laid out in a woodland to investigate the relationship between light intensity and blackberry growth. The percentage cover of blackberries and the light intensity were measured at 26 positions along this transect.



- a** Outline how these results indicate that blackberry distribution is limited by light intensity. [2]
- b** Distinguish between the transfer of matter and energy in closed ecosystems. [1]
- c** A pyramid of energy represents the amount of energy taken in by each trophic level per unit time and per unit area. Discuss the advantages and disadvantages of the use of pyramids of energy as models of energy flow in an ecosystem. [4]

Standard Level Paper 3, Time Zone 0, November 19, Q12a–c

- 2** The figure below shows the food web of a rocky shore community.



- a** The food web is a model of a real ecosystem. Using the food web as an example, explain what is meant by the term *model*. [3]
- b** Draw a food chain from this food web, showing at least three organisms. [1]
- c** Analyse the number of trophic levels occupied by seabirds in this food web. [1]

- 3 The mass of an individual organism can affect its physiology and feeding ecology.
- a State **one** process that results in the loss of carbon dioxide from a marine organism such as a crustacean or a jellyfish. [1]
 - b The crustacean and the jellyfish obtain carbon compounds by feeding. State **one** source of carbon for marine organisms, other than feeding. [1]
 - c Explain how energy enters, flows through and is lost from marine food chains. [3]
 - d Suggest with a reason whether having a large body mass is an advantage or disadvantage for jellyfish. [1]
- Standard Level Paper 2, Time Zone 2, May 21, Q4a–c, dii*
- 4 Life on Earth is based on carbon compounds, such as proteins, carbohydrates and lipids. Outline the recycling of carbon compounds in the carbon cycle. [7]
- 5 Explain the reasons for food chains rarely containing more than four or five trophic levels. [3]
- Standard Level Paper 2, Time Zone 0, November 21, Q3bii*
- 6 Describe how detritivores obtain nutrition and the effects they have in ecosystems. [4]
- Standard Level Paper 2, Time Zone 1, May 19, Q8a*
- 7 Explain the effect of combustion on the carbon cycle. [7]
- 8 Explain how climate determines the global distribution of biomes and the levels of biodiversity they contain. [9]
- 9 How do models help scientists explain the flows of energy through ecosystems? [9]

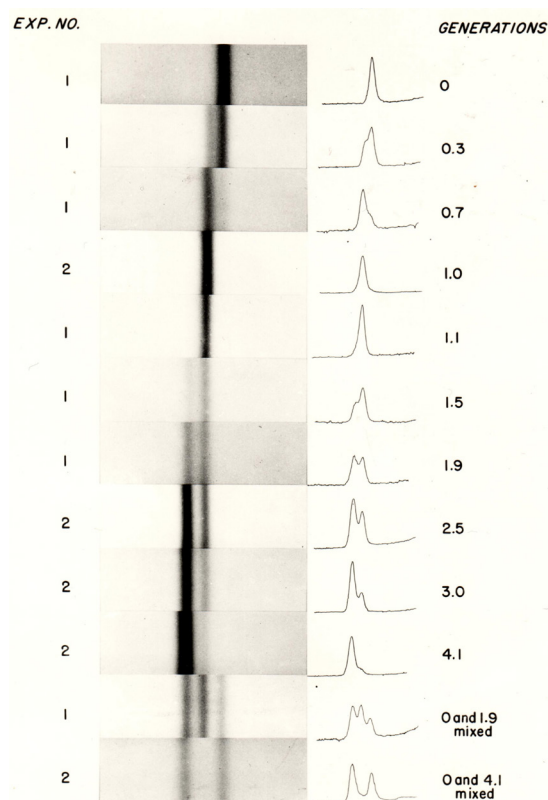
D1.1 DNA replication

Paper 1

- 1 How is the polymerase chain reaction (PCR) similar to the replication of DNA?
 - I DNA is heated to break hydrogen bonds
 - II DNA strands are separated
 - III Free nucleotides are used
 - IV DNA polymerase is required
 - A I only
 - B II and IV only
 - C I, II and III only
 - D II, III and IV only
- 2 What occurs as a result of base pairing during DNA replication?
 - A Both strands of the DNA have the same sequence of purines and pyrimidines
 - B In each strand, the number of purine bases equals the number of pyrimidine bases
 - C Purine bases in one strand become hydrogen-bonded to purine bases in the other strand
 - D The number of purine bases in one strand equals the number of pyrimidine bases in the other strand
- 3 Why can *Taq* polymerase be used in the polymerase chain reaction (PCR)?
 - A It ensures that primers match the end sequence of the DNA fragment
 - B It works with helicase in PCR
 - C It ensures desired sequences are amplified rather than non-target DNA
 - D It does not denature at high temperatures
- 4 Which are necessary to make DNA replication semi-conservative?
 - I Separation of the strands by RNA polymerase
 - II Complementary base pairing
 - III Use of a pre-existing strand as a template
 - A I and II only
 - B I and III only
 - C II and III only
 - D I, II and III

Standard Level Paper 1, Time Zone 2, May 17, Q9

- 5 Over 50 years ago, Meselson and Stahl investigated the mechanism of DNA replication. They transferred a rapidly growing population of *Escherichia coli* from a growth medium containing only ^{15}N to a growth medium with only ^{14}N . DNA samples were centrifuged at high speed in a salt density gradient. In the original published research, DNA molecules of the same density appear as a band in the UV absorption photographs as shown.



- a The density of the DNA band at generation 0 is 1.724 and the density of the dark band of DNA at generation 4.1 is 1.710. Estimate the density of the DNA band at generation 1.0. [1]
- b Describe the nitrogen composition of the DNA band in the *E. coli* at generation 1.0. [1]
- c Explain the pattern shown in generation 3.0. [3]
- d This experiment was designed to demonstrate whether replication was semi-conservative or conservative. Distinguish between semi-conservative replication and conservative replication. [2]

Standard Level Paper 3, Time Zone 0, May 16, Q2a–d

(Questions 6–8 HL only)

6 A drug blocks the activity of DNA primase. Which of the following would be affected by this drug?

- A Synthesis of a complete lagging strand
- B Synthesis of a complete leading strand
- C Synthesis of both a complete lagging strand and a complete leading strand
- D No effect, both strands would be synthesized normally

7 What is a function of DNA polymerase I?

- A Adds nucleotides in a 5' to 3' direction to elongate the chain
- B Uncoils the DNA double helix and splits it into two template strands
- C Removes RNA primer and replaces it with DNA
- D Produces sugar–phosphate bonds to link Okazaki fragments

Higher Level Paper 1, Time Zone 0, November 19, Q26

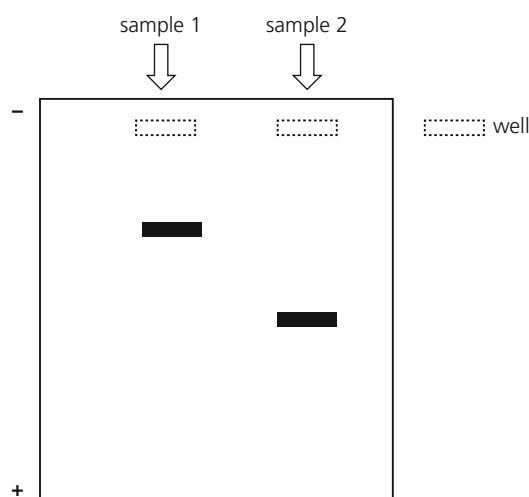
8 What are the functions of DNA primase and DNA polymerase I in DNA replication?

	DNA primase	DNA polymerase I
A	adds a short DNA primer to the template strand	replaces RNA with DNA in the Okazaki fragments of the leading strand
B	adds a short DNA primer to the template strand	replaces DNA primers with RNA
C	adds a short RNA primer to the template strand	replaces RNA with DNA in the Okazaki fragments of the leading strand
D	adds a short RNA primer to the template strand	replaces RNA primers with DNA

Higher Level Paper 1, Time Zone 2, May 19, Q12

Paper 2

1 A student researcher attempted to clone the human growth hormone (HGH) gene. Two separate samples of HGH DNA were obtained from DNA libraries and subjected to agarose gel electrophoresis. Results are shown below. Describe how the DNA fragments were separated into visible bands. [2]



2 Describe the polymerase chain reaction (PCR) and explain **one** advantage and **one** limitation of this procedure. [7]

3 Outline the process of DNA profiling. [4]

Higher Level Paper 2, Time Zone 1, May 21, Q8a

(Questions 4–8 HL only)

4 State **three** structural differences in the formation of the leading and lagging strands. [4]

5 Describe the role of DNA polymerase III in DNA replication. [4]

6 A drug blocks the activity of DNA ligase.

- a Describe what effect this drug would have on replication of the leading strand. [2]
- b Describe what effect this drug would have on replication of the lagging strand. [2]

7 Explain the role of proofreading in DNA replication. [4]

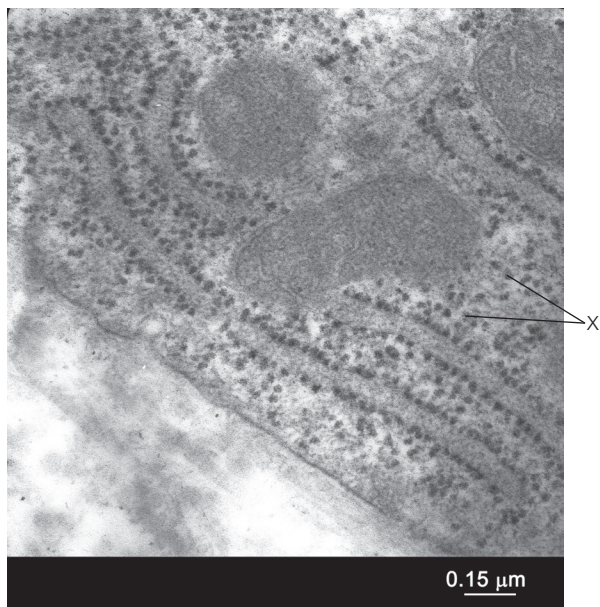
8 Explain the roles of specific enzymes in prokaryote DNA replication. [7]

Higher Level Paper 2, Time Zone 0, May 16, Q5b

D1.2 Protein synthesis

Paper 1

- 1 What is the primary function of the organelles labelled X in the electron micrograph?



- A Synthesizing lipids
- B Processing and packaging enzymes
- C Synthesizing proteins to be used within the cell
- D Synthesizing proteins to be secreted

- 2 The data shows part of the genetic code for mRNA.

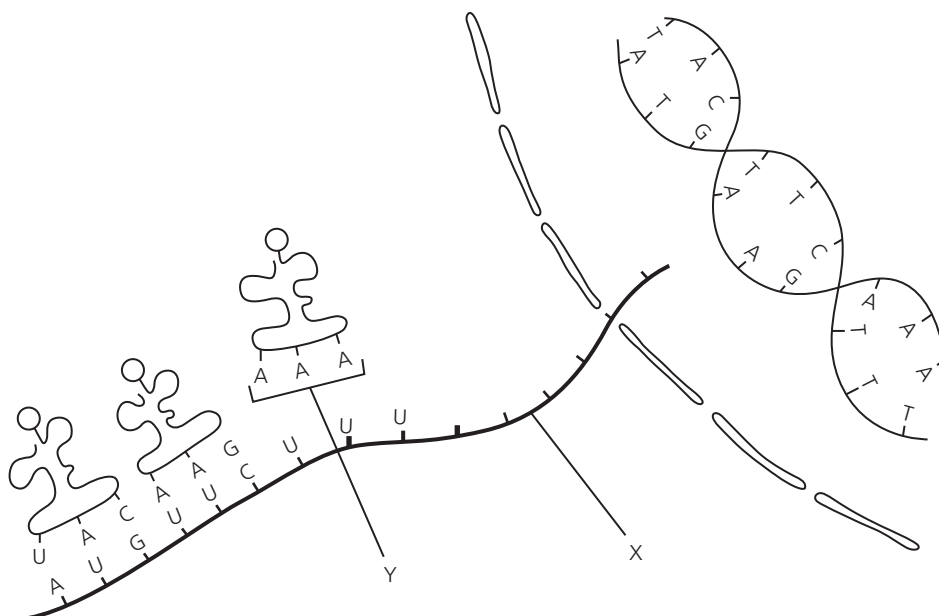
UUU	phenylalanine
UUC	phenylalanine
AAA	lysine
AAG	lysine

Which anticodon could be found on a tRNA molecule bonded to lysine?

- A AAG
- B UUC
- C TTT
- D GAA

Standard Level Paper 1, Time Zone 0, November 21, Q11

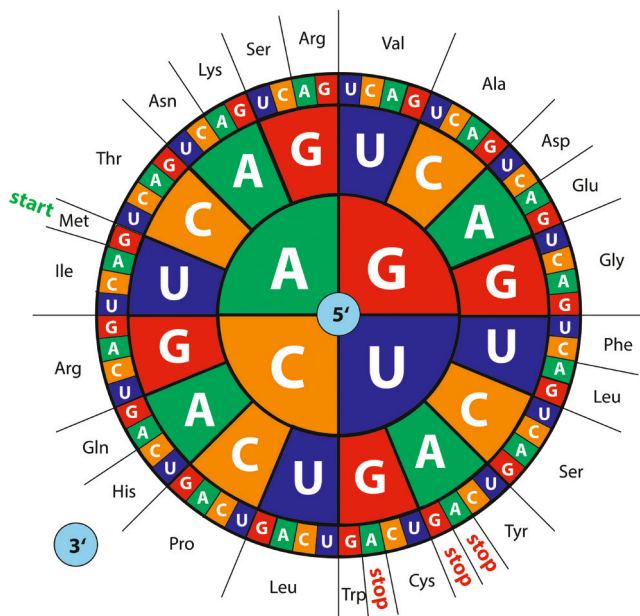
- 3 The diagram represents transcription and translation. What structures do the letters X and Y represent?



	X	Y
A	DNA	anticodon
B	mRNA	anticodon
C	DNA	codon
D	mRNA	codon

Standard Level Paper 1, Time Zone 0, November 20, Q9

- 4 The diagram shows mRNA codons.



The mRNA sequence UGGAACGUA codes for what amino acid sequence?

- A Glycine-Glutamine-Methionine
- B Methionine-Glutamine-Glycine
- C Threonine-Valine-Histidine
- D Tryptophan-Asparagine-Valine

Higher Level Paper 1, Time Zone 0, November 19, Q7

- 5 What do DNA replication, transcription and translation have in common?

- A Take place in cell nucleus
- B Require free nucleotides
- C Catalysed by polymerase
- D Complementary base pairing

Standard Level Paper 1, Time Zone 1, May 18, Q12

(Questions 6–13 HL only)

- 6 Which of the following statements correctly describes introns and/or exons in a eukaryotic cell?

- A Mutations to introns have no effect on the primary structure of protein
- B Different combinations of exons and introns allow more than one type of protein to be coded for by a gene
- C Exons are always translated into proteins
- D A single base-pair deletion on the first exon of a gene is likely to be more harmful than one that occurs on the last exon of a gene

- 7 Which regions of DNA code for the production of specific proteins?

- A Telomeres
- B Genes for ribosomal RNA
- C Exons
- D Regulators of gene expression

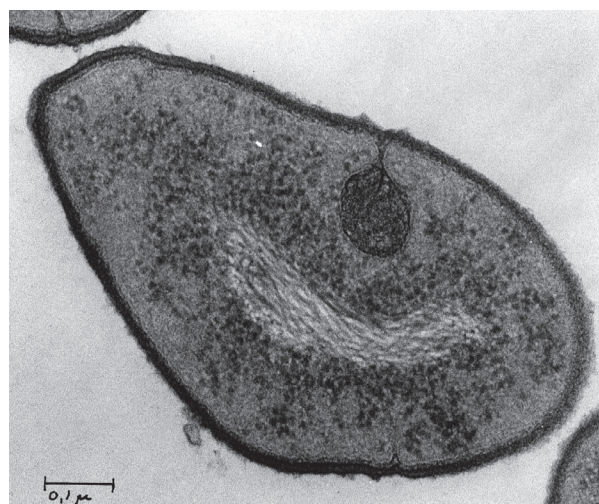
Higher Level Paper 1, Time Zone 1, May 21, Q26

- 8 Which statement applies to tRNA?

- A There is at least one type of tRNA that combines with each known amino acid
- B One type of tRNA can combine with all of the known amino acids
- C tRNA carries out its main role within the nucleus
- D tRNA is produced by the process of translation

Higher Level Paper 1, Time Zone 1, May 21, Q27

- 9 What is a feature of transcription in the single-celled organism shown in the electron micrograph?



- A mRNA splicing
- B Removal of introns
- C Codon–anticodon binding
- D Synthesis of RNA in a 5' to 3' direction

Higher Level Paper 1, Time Zone 2, May 21, Q27

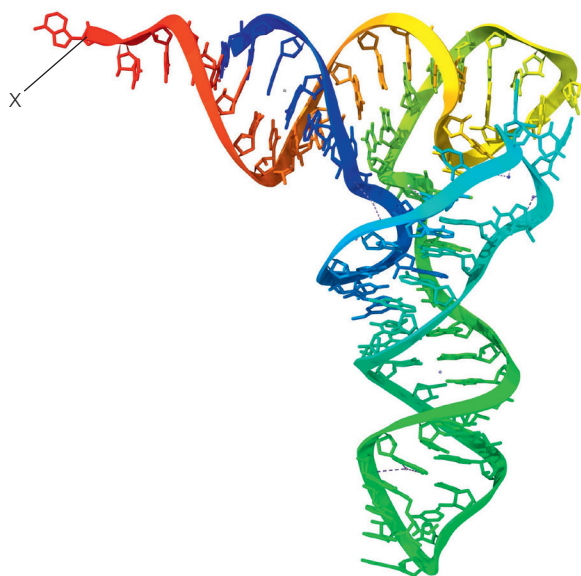
- 10 The number of protein-coding genes in the human genome is estimated to be about 20 000, which is much less than the size of the proteome. What is one reason for this?

- A Exons are removed from RNA before translation
- B There are more types of amino acids than nucleotides
- C mRNA can be spliced after transcription
- D Base substitutions occur during transcription

Higher Level Paper 1, Time Zone 0, November 20, Q26

- 11 The diagram shows the three-dimensional structure of tRNA.

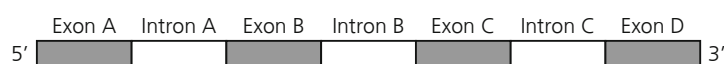
What can attach to the region marked X?



- A mRNA
- B An amino acid
- C An anticodon
- D The P site of the ribosome

Higher Level Paper 1, Time Zone 0, November 20, Q28

- 12 The diagram shows the arrangement of introns and exons in a segment of pre-mRNA. Pre-mRNA is immature mRNA containing introns and exons.



Which is a mature mRNA molecule derived from the pre-mRNA by splicing?

- A
- B
- C
- D

Higher Level Paper 1, Time Zone 1, May 19, Q27

- 13 Human DNA has been analysed and details of certain genes are shown in the table below.

Gene	Gene size / kb	mRNA size / kb	Number of introns
insulin	1.7	0.4	2
albumin	25.0	2.1	14
phenylalanine hydroxylase	90.0	2.4	12
dystrophin	2000.0	17.0	12

- a Calculate the average size of the introns for the albumin gene (show your workings).
- b With reference to the table shown, describe the relationship(s) between the gene size and the number of introns.

[2]

[2]

Paper 2

- 1 A short base sequence of mRNA and a table of the genetic code are shown below.

Sequence of mRNA:

AUGAGCCGAAGGUAGCUG

Table of the genetic code:

		2nd letter					
		U	C	A	G		
1st letter	U	Phe	Ser	Tyr	Cys	U	3rd letter
		Phe	Ser	Tyr	Cys	C	
		Leu	Ser	STOP	STOP	A	
		Leu	Ser	STOP	Trp	G	
	C	Leu	Pro	His	Arg	U	
		Leu	Pro	His	Arg	C	
		Leu	Pro	Gln	Arg	A	
		Leu	Pro	Gln	Arg	G	
	A	Ile	Thr	Asn	Ser	U	
		Ile	Thr	Asn	Ser	C	
		Ile	Thr	Lys	Arg	A	
		Met/START	Thr	Lys	Arg	G	
	G	Val	Ala	Asp	Gly	U	
		Val	Ala	Asp	Gly	C	
		Val	Ala	Glu	Gly	A	
		Val	Ala	Glu	Gly	G	

- a Outline the function of codons. [1]
b Determine the sequence of amino acids that could be translated from the sequence of mRNA. [1]
c Determine the DNA base sequence transcribed to form this sequence of mRNA. [1]

Standard Level Paper 2, Time Zone 0, November 19, Q2a–c

- 2 Describe the stages in the production of mRNA by transcription. [5]
3 Distinguish between transcription and translation. [4]
Higher Level Paper 2, Time Zone 0, November 17, Q7b
4 Outline how translation depends on complementary base pairing. [3]
Standard Level Paper 2, Time Zone 1, May 17, Q5a
7 Describe how the information carried on mRNA allows the synthesis of a complete polypeptide chain. [3]
8 a State one function for a region of DNA that does not code for proteins. [1]
b Outline the role of the A-site of ribosomes in translation. [1]
c Outline the role of tRNA-activating enzymes in translation. [2]
Higher Level Paper 2, Time Zone 2, May 18, Q2biii–cii

(Questions 5–12 HL only)

- 5 Telomeres are parts of chromosomes in eukaryotic cells.
a Describe the function of telomeres. [4]
b Suggest why bacteria do not have telomeres. [1]
6 5'-capping and 3'-polyadenylation are two kinds of post-transcriptional modifications that are present in eukaryotes but absent in prokaryotes.
Describe another post-transcriptional modification necessary to produce mature mRNA in eukaryotes. [2]
9 Describe the roles of the different binding sites for tRNA on ribosomes during translation. [5]
Higher Level Paper 2, Time Zone 2, May 17, Q6b (modified)
10 Describe the eukaryotic processing of pre-mRNA in terms of intron splicing, polyadenylation and 5' capping. [7]
11 Describe how protein synthesis in bacteria differs from that in plant cells. [7]
12 Explain how a polypeptide chain is synthesized in a eukaryotic cell. [7]

D1.3 Mutation and gene editing

Paper 1

- 1 Base substitution mutations can have the following molecular consequence except which one?
 - A Changes one codon for an amino acid into another codon for that same amino acid
 - B Codon for one amino acid is changed into a codon of another amino acid
 - C Reading frame changes downstream of the mutant site
 - D Codon for one amino acid is changed into a translation termination codon
- 2 What are single nucleotide polymorphisms (SNPs) caused by?
 - A Insertion mutations
 - B Deletion mutations
 - C Base substitution mutations
 - D Degeneracy of the genetic code
- 3 What are gene mutations caused by?
 - I Errors in DNA replication or repair
 - II Tobacco smoke
 - III UV radiation
 - A I only
 - B I and II
 - C II and III
 - D I, II and III
- 4 What does the inheritance of mutated genes occur via?
 - A Somatic cells
 - B Germ cells
 - C Skin cells
 - D Epithelial cells

(Questions 5–7 HL only)

- 5 Which of the following is the CRISPR-Cas9 system in bacteria similar to in the human body?
 - A Digestive system
 - B Immune system
 - C Circulatory system
 - D Respiratory system

- 6 CRISPR refers to repeated sequences in which of the following locations?
 - A Bacterial DNA
 - B Viral DNA
 - C Fungal DNA
 - D Viral RNA
- 7 Which of the following is the gene knockout technique used for investigating?
 - A Trauma on brain cells
 - B The process of DNA replication
 - C The function of a gene
 - D Mutation rate

Paper 2

- 1 State the meaning of the term *gene mutation* and outline the various types of gene mutations. [5]
- 2 DRD4 is a dopamine receptor in humans. The gene coding for the DRD4 receptor has many alleles, of which an individual can have only two.
Three alleles of the DRD4 receptor gene have the following mutations:
 - a single base substitution
 - a 21 base-pair deletion
 - a 13 base-pair deletion.The 13 base-pair deletion has the most serious consequences for the structure of the DRD4 receptor protein. Suggest why this is the case. [3]
- 3 Explain why substitution mutations may or may not change a single amino acid in a polypeptide. [5]
- 4 Explain, using an example, the consequences of a deletion mutation. [7]

(Questions 5–8 HL only)

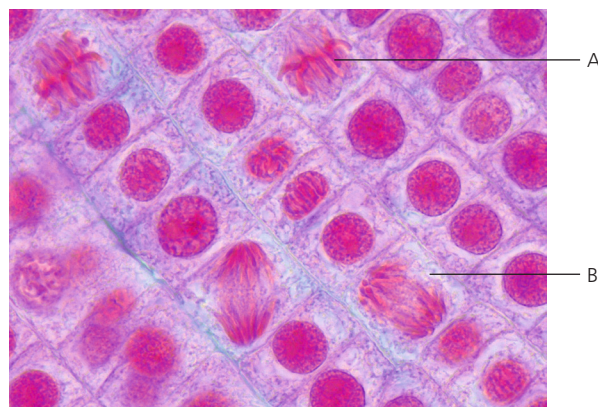
- 5 Outline the way scientists knock out a gene. Use a model organism to illustrate your answer. [5]
- 6 Outline how CRISPR sequences and the enzyme Cas9 are used in gene editing. [7]
- 7 Discuss how potential uses of CRISPR raise ethical issues that must be addressed before implementation. [7]
- 8 Suggest why highly conserved sequences in genes are identical or similar over long periods of evolution. [7]

D2.1 Cell and nuclear division

Paper 1

- 1 Which of the following best describes cytokinesis?
 - A The movement of cytoplasmic elements in mitosis
 - B A process that divides the cytoplasm and is the same in animal and plant cells
 - C The splitting of cytoplasm in a parent cell between daughter cells
 - D The process which precedes nuclear division
- 2 Which of the following include(s) the role of both mitosis and meiosis in eukaryotes?
 - I Avoiding the production of anucleate cells
 - II Maintaining the chromosome number in daughter cells
 - III Cell replacement, proliferation and growth
 - A I only
 - B I and II
 - C I, II and III
 - D III only
- 3 Cancer is a multi-step process. Some of the stages in cancer are listed. What is the correct sequence of events?
 - 1 Mutated cell undergoes uncontrolled cell division by mitosis
 - 2 Formation of a tumour
 - 3 Mutations in tumour suppressor genes and proto-oncogenes
 - 4 Cells from the primary tumour metastasize to other sites via the bloodstream
 - A 1 → 4 → 3 → 2
 - B 1 → 2 → 3 → 4
 - C 3 → 1 → 2 → 4
 - D 3 → 2 → 1 → 4
- 4 Nocodazole is a chemical used in the study of mitosis. It causes all mitotic cells to stop dividing at metaphase. Which statement(s) correctly identify how this chemical might work?
 - I Nocodazole inhibits chromatin condensing in the nucleus
 - II Nocodazole prevents replication of the centrioles
 - III Nocodazole stops sister chromatids migrating to opposite poles
 - A III only
 - B I, II and III
 - C I and II only
 - D I and III only

- 5 The figure shows cells of an onion root tip undergo mitosis.



- a i State the names of the stages of mitosis in the cells labelled A and B. [2]
- ii Outline differences between cells in stages A and B. [3]
- b i Suggest why the onion root tip was used to study mitosis. [1]
- ii Outline how the slide shown in the diagram may have been prepared. [3]

(Questions 6–9 HL only)

- 6 What process occurs in both mitosis and meiosis?
 - A Formation of chiasmata
 - B Reduction division
 - C Separation of chromatids
 - D Exchange of alleles between non-sister chromatids*Higher Level Paper 1, Time Zone 2, May 21, Q35*
- 7 In the cell cycle, when does DNA replication occur?
 - A Early metaphase
 - B C phase of interphase
 - C S phase of interphase
 - D G₂ phase of interphase
- 8 What forms when two different chromatids of the same homologous pair cross over?
 - A Sister chromatid
 - B A promoter region
 - C Chiasma
 - D Spindle fibre*Higher Level Paper 1, Time Zone 1, May 18, Q35 (modified)*

- 9 A sample from human epidermal tissue was examined under the microscope to determine a mitotic index. The number of cells in each stage of the cell cycle was determined. Data from the investigation is shown in the following table:

Stage of cell cycle	Interphase	Prophase	Metaphase	Anaphase	Telophase
Number of cells	100	18	12	5	2

- a Calculate the mitotic index for the tissue sample. [1]
 b Outline how the mitotic index can be used in the identification and treatment of cancer. [3]

Paper 2

- 1 Prokaryotic organisms such as *E. coli* divide by binary fission, not mitosis. Apart from ribosomes, prokaryotes have no organelles comparable to those found in eukaryotes and have a circular ‘chromosome’ with no centromere.
- With reference to the information above and your knowledge of mitosis, suggest why mitosis does not occur in prokaryotes. [2]

- 2 Distinguish between the terms *haploid* and *diploid*. [3]
 3 During an immune response, cells divide by mitosis. Suggest how mitosis is involved in an immune response. [3]
 4 Outline the process of mitosis and its role in maintaining genetic stability. [7]
 5 Explain the role of meiosis in natural selection and evolution. [7]

(Questions 6–10 HL only)

- 6 Outline the role of mitosis in growth and repair of tissue. [3]
 7 a Describe the phases of the cell cycle. [3]
 b Explain how the cell cycle is controlled. [5]
 8 Suggest why embryonic stem cells do not give rise to tumours. [3]
 9 Describe the development of cancer as a multi-step process. [3]
 10 Outline how mutations can affect the structure and function of an organism. [7]

D2.2 Gene expression (HL only)

Paper 1 (HL only)

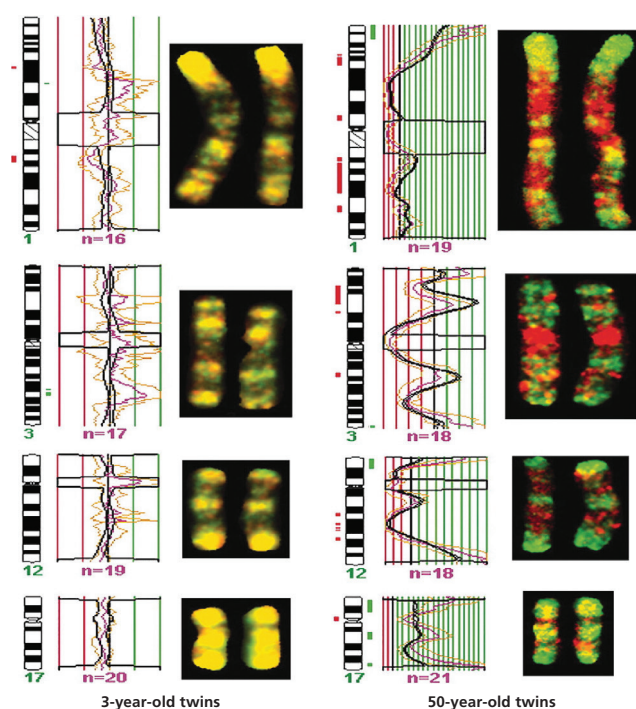
- Which of the following are used to regulate transcription?
 - Promoters
 - Enhancers
 - Transcription factors
 - I only
 - I and II
 - I, II and III
 - III only
- Which of the following best defines *epigenesis*?
 - The development of patterns of differentiation in the cells of a multicellular organism
 - Heritable changes in gene activity that are not caused by changes in the DNA base sequences
 - Generation of epidermal cells by mitosis
 - Process that occurs when an egg is fertilized by a sperm
- When glucose is absent and lactose is present, lactose binds to the operon's repressor. Which statement best describes what happens next?
 - Repressor binds to promoter, transcription is initiated
 - Repressor binds to operator, transcription is not initiated
 - Repressor fails to bind to structural genes, transcription is not initiated
 - Repressor fails to bind to the operator, transcription is initiated
- Which row of the table below gives the correct definitions of *genome*, *proteome* and *transcriptome*?

	Genome	Proteome	Transcriptome
A	the genetic code of an organism that determines which proteins are synthesized	the range of amino acids found in a cell at a particular time	the transcription factors used in protein synthesis
B	the genetic information contained within the nucleus of an organism	all the proteins expressed in an organism	the full range of mRNA molecules expressed from the genes of an organism
C	the whole of the genetic information of an organism	all the proteins expressed within a cell, tissue or organisms at a certain time	the range of mRNA transcripts produced in a specific cell or tissue type at a particular time
D	varies with the function, location or environmental conditions of the cell	the same in all the cells of an organism	depends on the differential expression of genes within a cell

- The images in the figure below show chromosomal regions with different amounts of methylation in two pairs of identical twins. The photomicrographs were taken during metaphase. The chromosome number is given for each chromosome (chromosomes 1, 3, 12 and 17 are shown).

For each chromosome, the diagrams show changes in levels of methylation between 3-year-old twins and 50-year-old twins.

Green areas indicate high levels of methylation (hypermethylation) in one twin compared to the other. Red areas indicate low levels of methylation (hypomethylation) in one twin compared to the other. Yellow areas indicate similar levels of methylation in both twins.



- Compare and contrast levels of methylation in chromosomes with increasing age of twins. [3]
- Suggest what the methylation patterns seen in the two sets of twins indicate. [4]

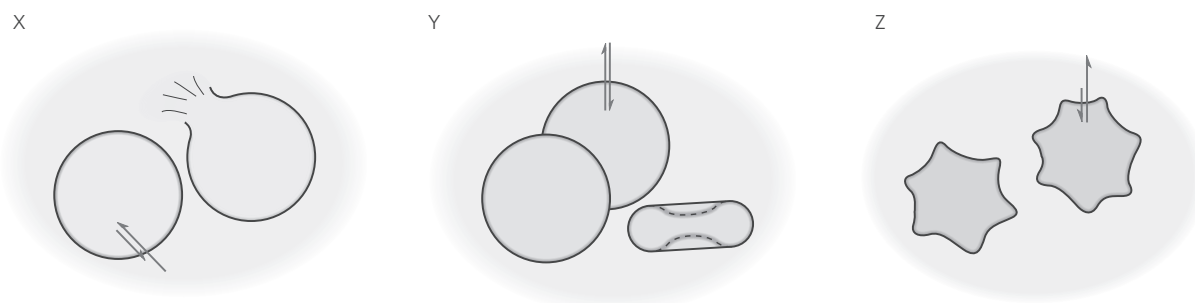
■ Paper 2 (HL only)

- 1 Describe the role of lactose in the regulation of lac operon. [3]
- 2 Describe and explain the effect of DNA methylation on the eukaryotic genome. [3]
- 3 Outline how monozygotic twin studies can be used to investigate the effects of the environment on gene expression. [7]
- 4 Explain the role of gene expression as the mechanism by which information in genes has effects on the phenotype. [7]
- 5 Describe the role of inhibition in controlling biological systems. [9]

D2.3 Water potential

Paper 1

- 1 Red blood cells were placed in solutions with different osmotic concentrations. The figure shows the effect of each solution on the cells. Which of the following correctly describes the solutions the red blood cells were placed in?



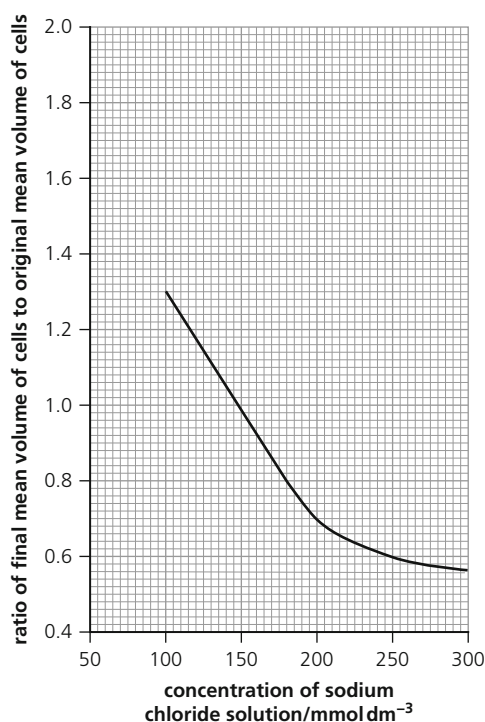
	X	Y	Z
A	hypertonic	hypotonic	isotonic
B	hypotonic	isotonic	hypertonic
C	isotonic	hypotonic	hypertonic
D	hypertonic	isotonic	hypotonic

- 2 Which of the following occur(s) by osmosis?

- I Absorption of water by soil
- II Gain of water from a plant cell in a hypotonic environment
- III Evaporation of water from the leaves of plants
- IV Absorption of water by cells in the walls of the digestive tract

- A I and IV
- B II and III only
- C II and IV only
- D I, II III and IV

- 3 The glucose concentration inside an animal cell is 6.5 mM dm^{-3} (where mM = millimole, or the amount of a substance equal to a thousandth of a mole). The glucose concentration in the solution surrounding the cell increases to 12.5 mM dm^{-3} . What will be the likely response?
- A The cell will gain water from the solution
 - B The cell will lose glucose to the surrounding solution
 - C The cell will lose water and shrink
 - D The cell will remain the same
- 4 Red blood cells were left for the same length of time in sodium chloride solutions of different concentrations. The final mean volume of the red cells was then compared with the original mean volume. The results are shown in the graph.



- a Use the terms *isotonic*, *hypotonic* or *hypertonic* to explain the results for red cells placed in a sodium chloride solution of the following concentrations:
- i 100 mmol dm^{-3} [2]
 - ii 150 mmol dm^{-3} [2]
 - iii 240 mmol dm^{-3} [2]
- b No intact cells could be seen in the 50 mmol dm^{-3} sodium chloride solution at the end of the experiment. Only fragments of membranes could be found. Explain why. [2]

(Questions 5–8 HL only)

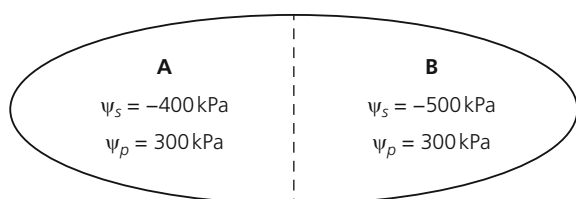
- 5 In which of the following solutions will a cell with a water potential of -10 kPa become turgid?

A -5 kPa
 B -20 kPa
 C -11 kPa
 D -10 kPa

- 6 Water moves through the root tissue of a plant. Which row of the table describes this movement?

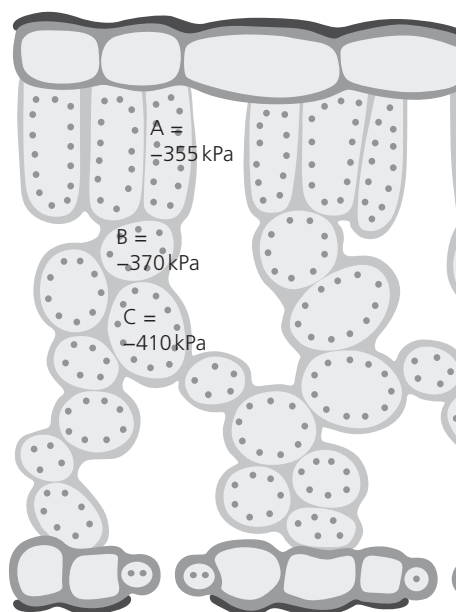
	Direction of water movement in terms of concentration of solutions	Direction of water movement in terms of water potential
A	concentrated to dilute	lower to higher
B	dilute to concentrated	lower to higher
C	concentrated to dilute	higher to lower
D	dilute to concentrated	higher to lower

- 7 The figure shows two chambers divided by a partially permeable membrane, containing solutions with different water potentials. The solute potential (Ψ_s) and pressure potential (Ψ_p) are given for both solutions.

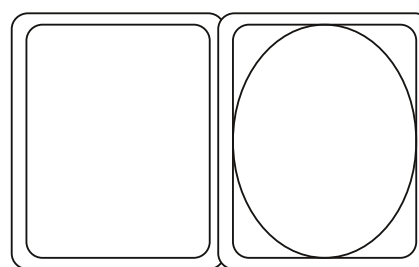


- a Calculate the water potential for side A. [1]
 b Calculate the water potential for side B. [1]
 c Draw an arrow on a copy of the diagram to indicate the direction of net water flow. [1]

- 8 The following diagram shows cells taken from the leaf of a plant. Cells A, B and C are next to each other. The water potential (Ψ_w) of each cell is shown.



- a i Draw arrows on a copy of the diagram to show the movement of water between these cells. [1]
 ii Explain your answer to part i in terms of water potential. [2]
 b The diagram below shows two plant cells, X and Y, seen through a microscope. The figures show the solute potential (Ψ_s) and the pressure potential (Ψ_p) for both cells and the water potential (Ψ_w) for cell Y.

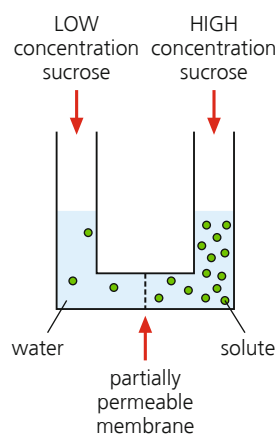


Cell X	Cell Y
$\Psi_p = 1000\text{ kPa}$	$\Psi_p = 0\text{ kPa}$
$\Psi_s = -1800\text{ kPa}$	$\Psi_s = -1000\text{ kPa}$
	$\Psi_w = -1000\text{ kPa}$

- i Calculate the water potential, Ψ_w , of cell X. Show your working. [2]
 ii State the name of the different conditions shown by cell X and cell Y, and explain how these conditions have arisen. [5]

Paper 2

- 1 The figure below shows a tube containing two different solutions: a dilute solution on the left and a concentrated solution on the right. The two solutions are separated by a partially permeable membrane.



- a Predict if the level of the solution will change on the left-hand or right-hand side of the capillary tube and, if so, in which direction. [1]
- b Explain your answer to part a. [3]

- 2 State **two** ways in which osmosis differs from facilitated diffusion. [2]
- 3 Jam contains a high concentration of sugar. Suggest why bacteria that cause decay do not grow in jam. [3]
- 4 Outline the effects of bathing plant tissues in a hypotonic solution. [5]
- 5 Describe how the osmotic concentration of tissue cells can be determined. [7]
- 6 Outline the role of the cell membrane in maintaining the osmotic concentration of cells. [9]

(Questions 7–8 HL only)

- 7 Suggest why marine plants are rare. [5]
- 8 Outline the contributions of solute potential and pressure potential to the water potential of cells with walls. [7]

D3.1 Reproduction

Paper 1

- 1 Which of the following statement(s) include differences between male and female gametes in sexual reproduction?
- I Male gamete is smaller
 - II Male gamete has fewer food reserves
 - III Female gametes are motile
- A** I only **C** I, II and III
B I and II **D** III only
- 2 Which of the following is an example of negative feedback in the menstrual cycle?
- A** Increasing FSH receptors in the follicles leading to increased oestradiol production
B Oestradiol inhibiting secretion of FSH from the pituitary gland
C Oestradiol stimulating the secretion of LH by the pituitary gland
D Progesterone continuing to stimulate the build-up of the endometrium
- 3 Which of the following statements is the definition of *fertilization*?
- A** Transfer of a male gamete to a female
B Generation of gametes by meiosis
C Fusion of a male and female gamete
D Production of a haploid cell from a diploid cell

(Questions 4–6 HL only)

- 4 What does the release of gonadotropin-releasing hormone directly stimulate?
- I Puberty
 - II Release of an ovum from an ovary
 - III Increased LH and FSH
- A** I only **C** I and III
B I and II **D** I, II and III
- 5 Which of the following is a mechanism to prevent polyspermy?
- A** Reduced meiotic division
B The cortical reaction
C Many sperm are produced but only one egg
D Increased spermatogenesis
- 6 Which hormone is detected by a pregnancy test?
- A** Insulin
B Epinephrine
C Thyroxin
D Human chorionic gonadotropin

Paper 2

- 1 **a i** Draw and annotate a fully labelled half-flower diagram of an insect-pollinated flower you have studied. [4]
ii State what insects may visit this flower. [1]
iii Identify the features of this flower that may attract insects. [2]
- b** Explain how pollination is brought about in an animal-pollinated flower. [4]
- 2 State the name of the hormones that:
- a** trigger ovulation [1]
b stimulate the growth of the endometrium [1]
c maintain the endometrium and promote its vascularisation. [1]
- 3 Distinguish between asexual and sexual reproduction. [3]
- 4 Explain how meiosis breaks up parental combinations of alleles, and how fusion of gametes produces new combinations. [4]
- 5 Describe the use of hormones in IVF treatment. [5]
- 6 Outline how meiosis and two other mechanisms promote genetic variability among individuals of the same species. [7]

(Questions 7–11 HL only)

- 7 **a** Explain how the placenta is adapted to its function. [3]
b List the substances exchanged between the foetus and the mother. [2]
c State which processes are used to transfer substances to the foetal blood at the placenta. [2]
d Suggest why is it essential that maternal and foetal blood circulations do not mix in the placenta. [2]
- 8 Outline the role of mitosis and meiosis in gametogenesis. [6]
- 9 Distinguish between spermatogenesis and oogenesis. [3]
- 10 Describe the hormonal control of pregnancy and childbirth. [7]
- 11 Outline the role of chemical signalling in the control of pregnancy and childbirth. [7]

D3.2 Inheritance

Paper 1

- Which of the following is an example of a sex-linked genetic disorder?
 - Phenylketonuria
 - Haemophilia
 - Sickle-cell anaemia
 - Huntington's disease
- Which of the following is a definition of *phenotype*?
 - Capacity to develop traits suited to the environment
 - The observable traits of an organism
 - The combination of alleles inherited by an organism
 - Mutation in an autosomal gene that codes for an enzyme
- Which of the following is a description of *incomplete dominance*?
 - Heterozygotes have an intermediate phenotype
 - Heterozygotes have a dual phenotype
 - A heterozygous genotype will produce the same phenotype as one that is homozygous dominant
 - More genes are carried by the X chromosome than the Y chromosome

(Questions 4–8 HL only)

- Which of the following describes unlinked genes?
 - Segregate in meiosis I
 - Undergo independent assortment
 - Are mainly found on the X chromosome
 - I only
 - I and II
 - I, II and III
 - III only
- A dihybrid cross with individuals that are heterozygous for both genes will result in which of the following phenotype ratios?
 - 3:1
 - 1:1:1:1
 - 9:3:3:1
 - 1:2:1

- A dihybrid cross was carried out between two plants to determine whether the genes for seed shape and colour are linked. If the genes are unlinked, the expected ratio of 9:3:3:1 should occur. A chi-squared test was carried out on the observed results of the cross. The critical value for chi-squared at the 5% level of significance in this test was 7.82. The calculated value for chi-squared was 6.25. What can be concluded from this data?
 - The results prove that the genes are linked
 - The results prove that the genes are unlinked
 - There is significant evidence that the genes are linked
 - There is significant evidence that the genes are unlinked

Higher Level Paper 1, Time Zone 1, November 21, Q35

- This is the cross that led to the discovery of non-Mendelian ratios in Morgan's experiments with *Drosophila*.

Grey body – Normal wings		Black body – Vestigial wings
$\frac{b^+ \quad vg^+}{b \quad vg}$	×	$\frac{b \quad vg}{b \quad vg}$

Which is the recombinant genotype?

- | | | | |
|----------|---|----------|-----------------------------------|
| A | $\frac{b^+ \quad vg^+}{b \quad vg}$ | B | $\frac{b \quad vg}{b \quad vg^+}$ |
| C | $\frac{b^+ \quad vg^+}{b^+ \quad vg^+}$ | D | $\frac{b \quad vg}{b \quad vg}$ |

Higher Level Paper 1, Time Zone 0, May 16, Q22

- 8 An investigation was carried out on the inheritance of flower colour in an ornamental plant. The results are shown in Table 1.

■ **Table 1** Outcome of a genetic cross investigating the inheritance of flower colour of an ornamental plant

P generation	Red flowered × white flowered	
F1	All red-flowered plants	
	F1 generation allowed to self-fertilize	
F2	156 red-flowered plants	44 white-flowered plants

- a Using a copy of Table 2, calculate χ^2 . [2]

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

■ **Table 2** Chi-squared calculation for flower colour observed and expected results

Category	Predicted	O	E	O - E	(O - E) ²	(O - E) ² /E
red-flowered plants	3	156				
white-flowered plants	1	44				
total						

- b Using the table of critical values (Table 3), determine whether there is a significant difference between the observed and expected results. [2]

■ **Table 3** Table of critical values for chi-squared test

Degrees of freedom	Probability greater than							
	0.99	0.95	0.90	0.50	0.10	0.05	0.01	0.001
df = 1	0.00016	0.004	0.016	0.455	2.71	3.84	6.63	10.83
df = 2	0.0201	0.103	0.21	1.386	4.60	5.99	9.21	13.82

- c Explain what the results show about the pattern of inheritance of flower colour in the ornamental plant. [3]

Paper 2

- 1 The inheritance of ABO blood groups is controlled by three alleles of a gene (I^A , I^B and i). The alleles I^A and I^B are codominant.

- a Explain what is meant by the terms:
- i allele [1]
 - ii codominant. [1]
- b State all possible genotypes for the following blood types:
- i A [1]
 - ii B [1]
 - iii O [1]
 - iv AB. [1]

Offspring of blood group A and O were born to parents of blood groups A and B.

- c Construct a genetic diagram to show the possible ABO blood group phenotypes of these children. [4]

- 2 Distinguish between the following pairs:
- a discontinuous variable and continuous variable [2]
 - b autosomes and sex chromosomes [2]
 - c X chromosomes and Y chromosomes. [2]

- 3 Explain what is described as continuous variation by using one named example. [4]

- 4 Mendel carried out a breeding experiment with garden pea plants in which pure-breeding pea plants grown from seeds with a smooth coat were crossed with plants grown from seeds with a wrinkled coat. All the seeds produced (the F1 generation) were found to have a smooth coat. When plants were grown from these seeds and allowed to self-pollinate, the second generation of seeds (the F2 generation) included both smooth and wrinkled seeds in the ratio of 3:1.

- a In Mendel's explanation of his results he used the term *hereditary factor*.
- i Identify the modern term for 'factor'. [1]
 - ii State where in the cell they occur. [1]
- b The parent plants have diploid cells, while the gametes (sex cells) are haploid. Define what is meant by *haploid* and *diploid*. [2]
- c By reference to the above experiment, define the following terms and give an example of each:
- i homozygous and heterozygous [2]
 - ii dominant and recessive [2]
 - iii genotype and phenotype. [2]
- d Using appropriate symbols for the alleles for smooth and wrinkled coat, construct a genetic diagram, using a Punnett grid, to show the behaviour of the alleles in this experiment. [4]

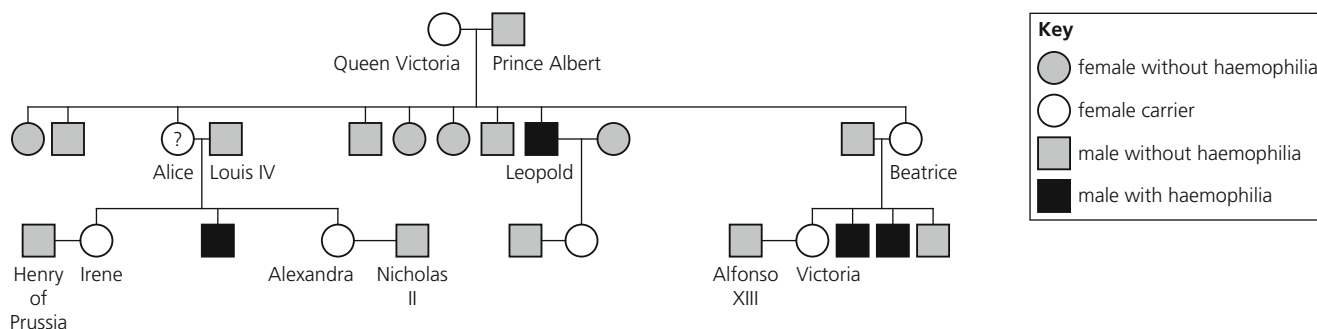
(Questions 5–9 HL only)

- 5 Distinguish between the following pairs:
- a monohybrid cross and dihybrid cross [2]
 - b linkage and crossing over [4]
 - c multiple alleles and polygenes. [4]
- 6 Mendel conducted many experiments with garden pea plants, but some later geneticists used the fruit fly *Drosophila* in experimental investigations.
- a Suggest three reasons why this insect was found to be useful. [3]
- b When dihybrid crosses are carried out, the progeny are rarely present in the exact proportions predicted. Explain why small deviations of this sort arise in dihybrid crosses with:
- i garden pea plants [3]
 - ii *Drosophila*. [3]

- 7 In *Drosophila*, mutants with scarlet eyes and vestigial wings are recessive to flies with red eyes and normal wings. (These contrasting characters are controlled by single genes on different chromosomes, i.e. they are not linked on a single chromosome.)

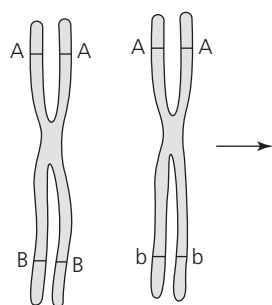
Explain the phenotypic ratio to be expected in the F₂ generation when normal flies are crossed with scarlet eyes/vestigial wing mutants and sibling crosses of the F₁ offspring are then conducted. Show your reasoning by means of a genetic cross diagram. [7]

- 8 Haemophilia is a sex-linked disease that affected some members of royal families in Europe during the nineteenth and twentieth centuries.



- a i Draw a Punnett grid to show all the possible genotypes of Queen Victoria's children. [2]
ii Deduce the genotype of Queen Victoria's daughter Alice. [1]

The diagram shows the structure of two chromosomes after the first division of meiosis, assuming that there was no crossing over or chiasmata formation.



- b i Draw the same chromosomes to show their structure at the same stage of meiosis if there had been one chiasma between two gene loci. [1]
ii State the stage of meiosis where chiasmata formation may occur. [1]
c Explain gene linkage and its effects on inheritance. [2]
d Explain the mechanism that prevents polyspermy during fertilization. [2]

Higher Level Paper 2, Time Zone 0, November 21, Q2ai–c

- 9 Autosomal genes are located in chromosomes that are not sex chromosomes. The inheritance of autosomal genes is affected by whether the genes are linked or unlinked. Explain the **two** types of inheritance, using the example of parents that are heterozygous for two genes A and B. [7]

Higher Level Paper 2, Time Zone 2, May 21, Q5a

D3.3 Homeostasis

Paper 1

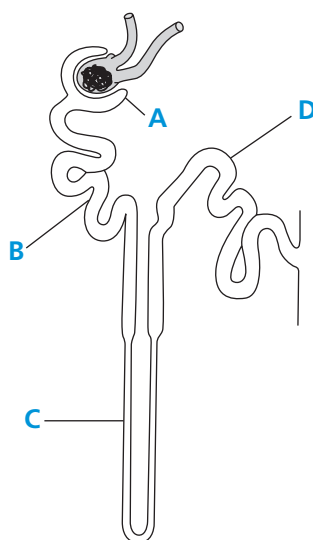
- 1 After eating a meal, which hormone is secreted and which cell secretes it?

	Hormone	Cell in pancreas
A	glucagon	α cells
B	glucagon	β cells
C	insulin	α cells
D	insulin	β cells

- 2 Which of the following describes homeostasis?
- I Maintenance of the internal environment of an organism
 - II Involves negative feedback loops
 - III Involves positive feedback loops
- A I only
B I and II
C I and III
D III only
- 3 Which of the following are involved in thermoregulation?
- A Hypothalamus, pituitary gland and thyroxine
B Pancreas, insulin and glucagon
C Adrenal gland and adrenalin
D Hypothalamus, pituitary gland and FSH

(Questions 4–6 HL only)

- 4 Where in the nephron is most glucose reabsorbed?



Higher Level Paper 1, Time Zone 1, November 21, Q39

- 5 What is the function of the loop of Henle?
- A To reabsorb glucose
B To maintain a hypotonic solution in the medulla
C To maintain a hypertonic solution in the medulla
D To excrete urea

Higher Level Paper 1, Time Zone 2, May 19, Q33 (modified)

- 6 What is the effect of ADH on the kidney?
- A It stimulates reabsorption of glucose in the proximal convoluted tubule
B It inhibits reabsorption of water in the Bowman's capsule
C It stimulates reabsorption of water in the collecting duct
D It stimulates reabsorption of ions in the loop of Henle

Higher Level Paper 1, Time Zone 2, May 18, Q39 (modified)

Paper 2

- 1 Explain the role of negative feedback loops in homeostasis, using a specific example. [5]
- 2 Describe the mechanisms for thermoregulation in humans. [7]
- 3 Discuss the control of blood glucose levels and the consequences if they are not maintained. [8]
- Standard Level Paper 2, Time Zone 2, May 19, Q6c
- 4 Outline how homeostatic mechanisms allow organisms to adapt to their environment. [7]

(Questions 5–6 HL only)

- 5 a State the differences in composition of blood proteins, glucose and urea found in:
- i blood before entering the glomerulus [1]
 - ii glomerular filtrate in the Bowman's capsule [1]
 - iii filtrate inside the descending limb of the loop of Henle. [1]
- b Explain how water reabsorption is controlled in the collecting duct. [4]
- 6 Outline the kidney's role in osmoregulation. [8]

Higher Level Paper 2, Time Zone 0, November 20, Q7c (modified)

D4.1 Natural selection

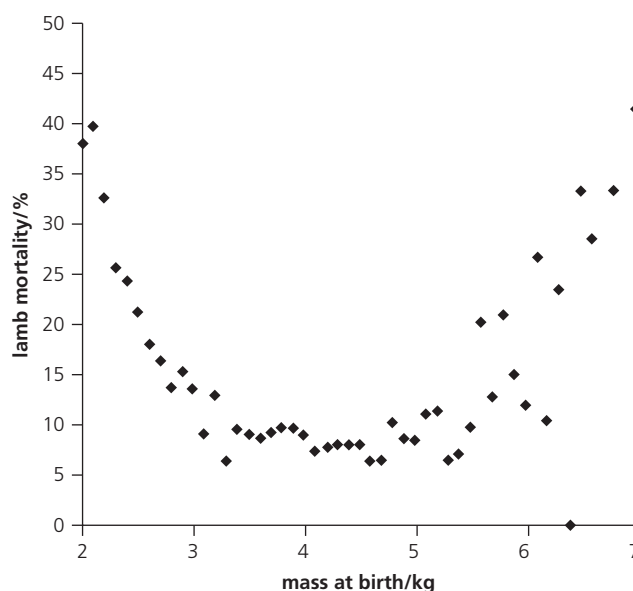
Paper 1

- 1 Which observation best describes the process of natural selection?
 - A A change from simple to more complex organisms over time
 - B A change in size of the population over time
 - C Different rates of reproductive success of different genotypes
 - D Spontaneous occurrence of advantageous mutations
- 2 Which one of the following is not included in Lamarck's ideas about the process of evolution?
 - A Acquired characteristics are inherited
 - B Organisms arise by spontaneous generation
 - C Evolutionary relationships among organisms can be depicted by groupings based on similarity
 - D Organisms develop adaptations to the environment through the use and disuse of organs
- 3 Which of the following is an example of a density-independent factor that may affect the survival of individuals in a population?
 - A Predation
 - B Transfer of pathogens
 - C High or low temperatures
 - D Competition for limited resources
- 4 Which of the following is a description of sexual selection?
 - A Process where organisms better adapted to their environment survive and produce more offspring than competitors
 - B Selection arising through preference by one sex for certain characteristics in individuals of the other sex
 - C Selection in breeding, carried out deliberately by humans to alter populations
 - D Process by which distantly related organisms independently evolve analogous traits under similar selection pressures

(Questions 5–7 HL only)

- 5 A population's gene pool was found to have been unchanged for many generations. Which of the following conditions must have existed in the population?
 - A Mating had always been random
 - B Genetic drift had often occurred
 - C Inbreeding has occurred
 - D Certain alleles are at selective advantage

- 6 Which of the following is a definition of *disruptive selection*?
 - A Mechanism that maintains a favourable characteristic and the alleles responsible for it
 - B Occurs when particular environmental conditions favour the extremes of a phenotypic range
 - C In changing environmental conditions, the majority form of an organism may become unsuited to the environment
 - D Mechanism where one species excludes another from an environment
- 7 The graph shows the relationship between mass at birth and the percentage that die shortly after birth for Scottish Blackface lambs.



What type of selection for the lambs is shown in the graph?

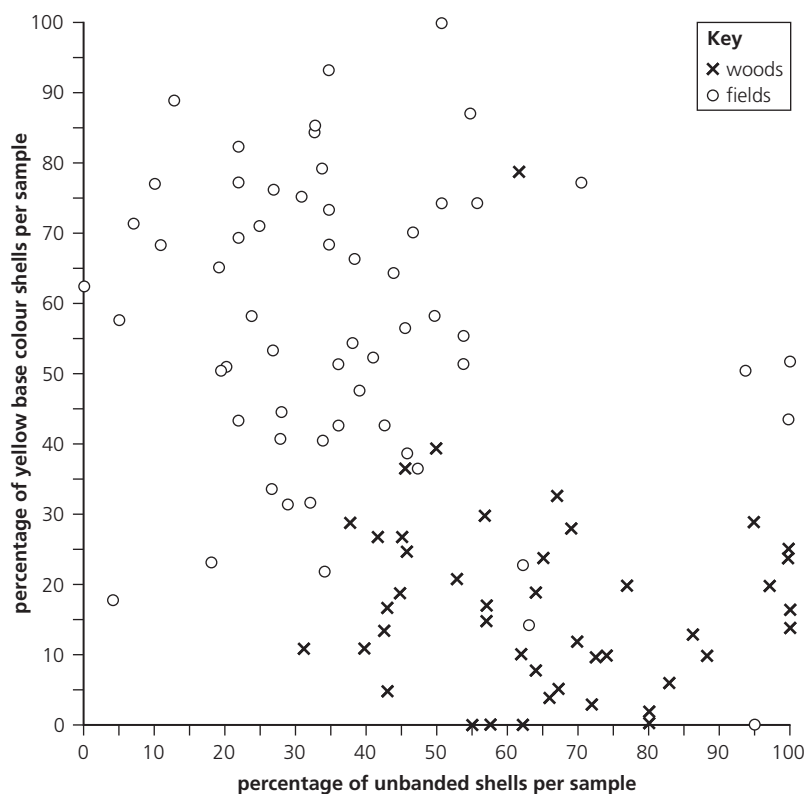
- A Disruptive selection, as there is a drop in mortality at intermediate birth masses
- B Stabilizing selection, as lambs with low or high birth mass are less likely to survive
- C Directional selection, as lambs with a high birth mass have high mortality
- D There is no evidence in the graph of selection, as survival frequency is not shown

Higher Level Paper 1, Time Zone 1, November 21, Q36

Paper 2

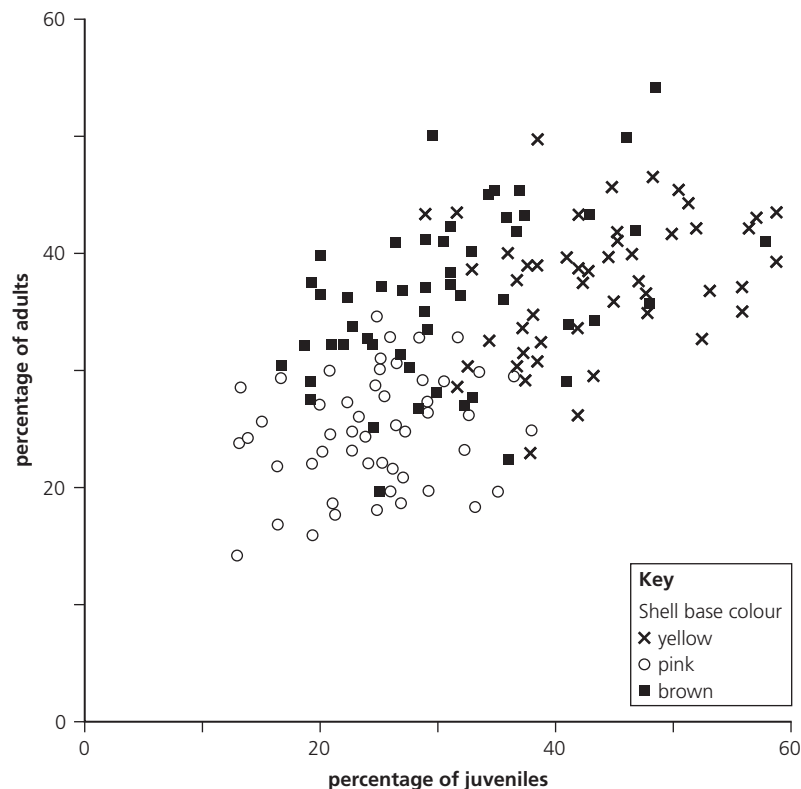
- 1 The land snail *Cepaea nemoralis* is very common in North America and in Europe. The base colour of its shell varies between brown, pink and yellow, and also in its intensity. Some shells are unbanded, but most show one to five bands of different width on top of the shell base colour.

In the early 1950s, scientists studied the proportion of colours and banding of *C. nemoralis* in woods and fields near Oxford, UK, which differed in the type of plants and background colour. Each data point on the graph represents the percentage of yellow base colour shells and unbanded shells in a sample from either one type of wood or field, although other snail colours were present.



- Determine the maximum percentage of yellow base colour shells found in woods. [1]
- Suggest either **one** possible advantage or **one** disadvantage of having a banded shell, stating whether it is an advantage or disadvantage. [1]
- Using the data in the graph, distinguish between the distribution of *C. nemoralis* shells in woods and fields. [2]

The population of *C. nemoralis* has been studied for many years in open fields in a similar area. In the following graph, each data point represents the percentage of adults of a given base colour plotted against the percentage of juveniles of the same base colour collected each year.



- d Deduce from the data in the graph which shell base colours are on average most and least frequent among adult snails. [2]
- e Discuss whether there is evidence in the data that colour plays a role in the survival of the snails. [3]
- f Using the theory of natural selection, explain the differences shown in the graph between the three colours of snail. [3]

Standard Level Paper 2, Time Zone 1, May 18, Q1a–f

- 2 Some lice live in human hair and feed on blood. Shampoos that kill lice have been available for many years but some lice are now resistant to those shampoos. Two possible hypotheses are shown in the table.

Discuss which hypothesis is a better explanation of the theory of evolution by natural selection.

Hypothesis A	Hypothesis B
Resistant strains of lice were present in the population. Non-resistant lice died with increased use of anti-lice shampoo and resistant lice survived to reproduce.	Exposure to anti-lice shampoo caused mutations for resistance to the shampoo and this resistance is passed on to offspring.

[3]

Standard Level Paper 2, Time Zone 2, May 17, Q4bii

- 3 Suggest how natural selection could have brought about the evolution of the skeleton of a bat's wing. [5]
- 4 Compare and contrast natural selection and sexual selection. [5]
- 5 Referring to each level of biological organization, outline how natural selection leads to evolution. [7]

(Questions 6–8 HL only)

- 6 Explain what is meant by directional, stabilizing and disruptive selection. Give examples of each type of selection. [6]
- 7 Outline how allele frequencies in gene pools can be used to assess whether natural selection is taking place. [7]
- 8 Discuss whether or not the evolution of antibiotic resistance in bacteria is an example of artificial selection. [6]

D4.2 Stability and change

Paper 1

- Which of the following are required for stability in ecosystems?
 - Supply of energy
 - Recycling of nutrients
 - Genetic diversity
 - I only
 - I and II
 - I, II and III
 - II and III
- Which of the following is most likely to be an example of a possible tipping point in ecosystem stability?
 - Deforestation of the Amazon rainforest
 - Bleaching of coral reefs
 - Unsustainable harvesting of aquatic ecosystems
 - Eutrophication of aquatic and marine ecosystems due to leaching
- Which of the following is an established method of rewilding?
 - Introduction of herbivores
 - Habitat fragmentation
 - Reintroduction of apex predators
 - Removal of keystone species

(Questions 4–6 HL only)

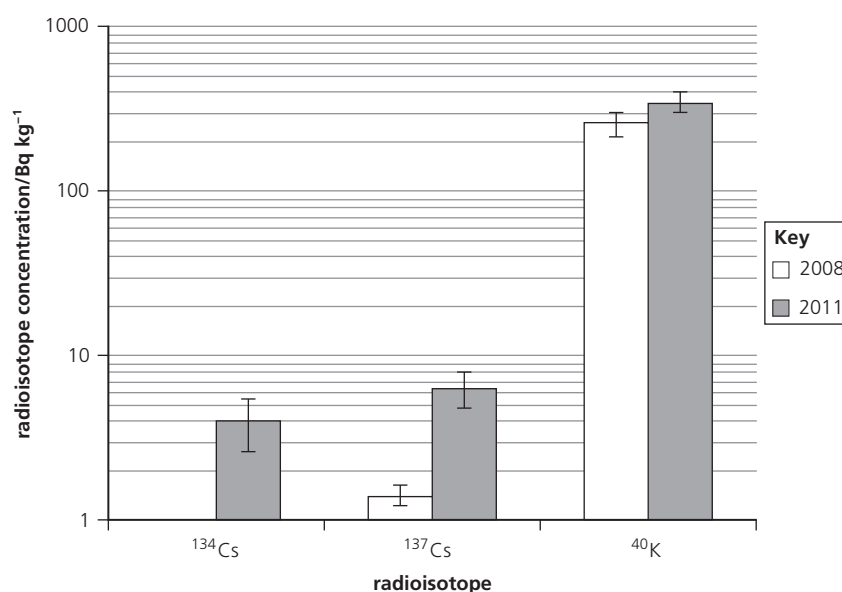
- Which of the following is a definition of *succession*?
 - Separation of communities into specific zones according to variables such as altitude
 - The process of change over time in a community
 - The process of change over distance in a community
 - The movement of energy and biomass through a food chain
- Which of the following describes changes from pioneer to climax community in a succession?

	Size of plants	Species diversity	Complexity of food webs	Amount of nutrient cycling
A	decreases	increases	decreases	increases
B	increases	decreases	increases	decreases
C	increases	increases	increases	increases
D	decreases	decreases	decreases	decreases

- Which of the following ecosystems is an example of cyclical succession?
 - Tropical rainforest
 - Wood pasture
 - Coral reef
 - Taiga

Paper 2

- Bluefin tuna (*Thunnus orientalis*) are top carnivores in the marine ecosystem. Some radioisotopes of elements are produced by nuclear reactors. Following a nuclear accident at Fukushima in Japan in March 2011, the levels of certain radioisotopes were measured in the bodies of bluefin tuna caught off California in August 2011, the other side of the Pacific Ocean from Japan. The becquerel (Bq) is a measure of radioactivity.

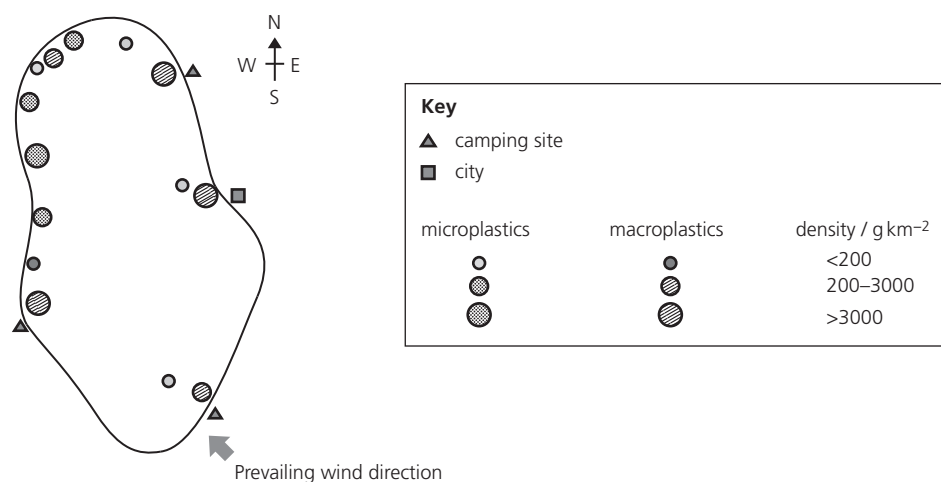


Explain how the levels of the caesium (Cs) radioisotopes could have accumulated in the tissues of these fish.

[3]

Standard Level Paper 3, Time Zone 0, November 19, Q14a

- 2 The sketched map shows the density of microplastics and macroplastics found in a lake within a national park.



- Predict **one** example of macroplastic pollution that is likely to be found in this lake. [1]
- State **two** possible effects on organisms of microplastic pollution. [2]
- Outline the effect of wind on the distribution of plastic pollution in this lake. [2]
- Suggest changes in the management of the national park that could reduce the amount of macroplastic pollution. [3]

Higher Level Paper 3, Time Zone 0, November 16, Q15a–d

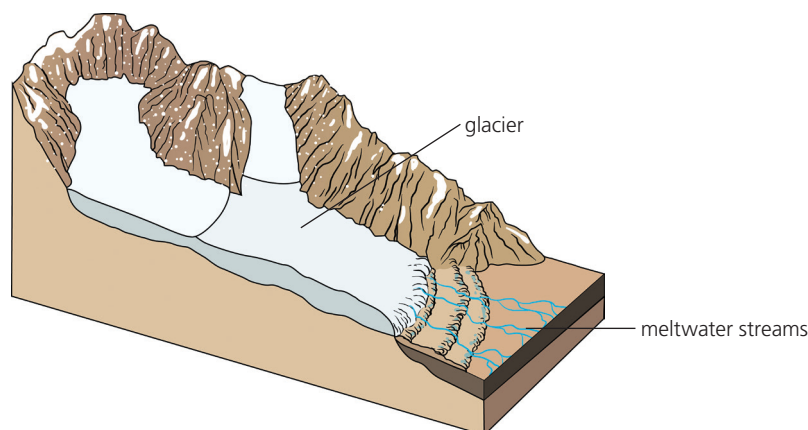
- 3 Extensive areas of the rainforest in Cambodia are being cleared for large-scale rubber plantations. Distinguish between the sustainability of natural ecosystems such as rainforests and the sustainability of areas used for agriculture. [3]

Higher Level Paper 2, Time Zone 0, November 18, Q8a

- Outline the role of keystone species in the sustainability of ecosystems. [4]
- Describe how leaching of nitrogen and phosphate fertilizers causes eutrophication. [5]
- Explain how the sustainability of resource harvesting from natural ecosystems can be assessed. [5]
- Explain how stability is a function of each level of biological organization. [6]

(Questions 8–12 HL only)

- 8 A retreating glacier leaves an environment of lifeless glacial deposits, including sands and gravels. Retreating glaciers often offer suitable sites for primary succession.



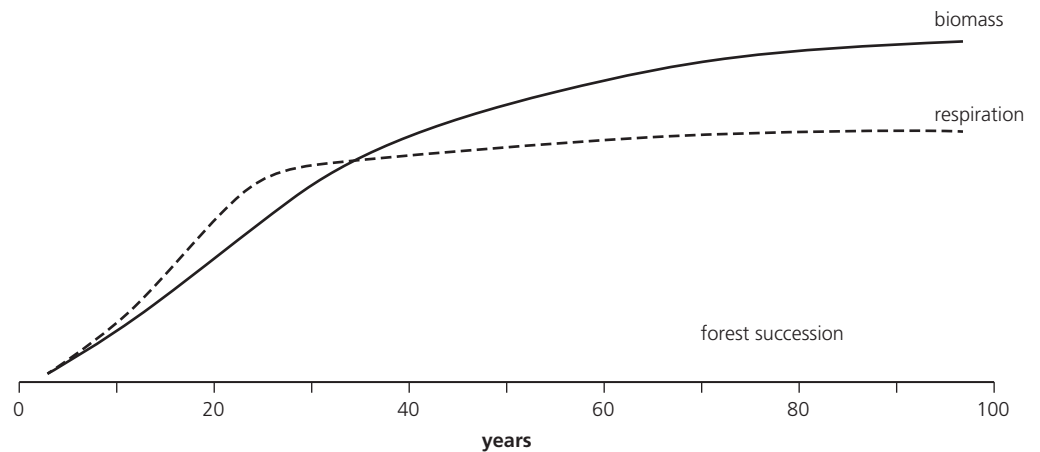
- State **one** abiotic factor that will determine the type of ecosystem in a succession. [1]
- Predict the process of succession that takes place on exposed bare ground as the glacier retreats. [3]

Higher Level Paper 3, Time Zone 1, May 18, Q15a–b

- 9 Primary plant succession has been observed in sand dunes adjacent to the northern end of Lake Michigan, one of the Great Lakes in North America. The youngest sand dunes have beach grass (*Ammophila breviligulata*) and prairie bunch grass (*Schizachyrium scoparium*). The oldest dunes have coniferous trees (*Pinus strobus* and *Pinus resinosa*).
- Predict the differences in the soil characteristics between the youngest and oldest sand dunes. [3]
 - Outline how the type of stable ecosystem that will develop in an area can be predicted based on climate. [3]

Standard Level Paper 3, Time Zone 0, May 16, Q14a–b

- 10 The graph is a model showing biomass and respiration levels in a field where farming stops at time zero and the abandoned land develops into forest.



- Describe the change in biomass over the 100-year period. [2]
- Outline the evidence from the graph that the area had plentiful rainfall. [2]
- Explain the changes in biomass. [2]
- Suggest why biomass continues to increase after the respiration levels plateau. [2]

Higher Level Paper 3, Time Zone 0, May 16, Q16a–d (modified)

- Explain how changes occur during primary succession. [6]
- Outline how human influences can prevent climax communities from developing. [5]

D4.3 Climate change

Paper 1

- 1 Which of the following describes a positive feedback concerning climate change?
- A Increased atmospheric temperature results in the melting of sea ice, which decreases the amount of solar radiation reflected back into space
 - B Increased burning of fossil fuels increases atmospheric CO₂ concentration, enhancing the greenhouse effect
 - C Melting of glaciers causes an increase in sea levels
 - D Increase in atmospheric temperature causes many species to move towards increased altitudes to stay within their optimum temperature range
- 2 The emission of greenhouse gases such as CO₂ and CH₄ have different impacts on global warming depending on their concentration in the atmosphere, their atmospheric lifetime and their global-warming potential (GWP). GWP was developed to allow comparisons of the global warming impacts of different gases, and is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO₂). Which row best describes the characteristics of these greenhouse gases?

	CO ₂	CH ₄
A	higher GWP	lower GWP
B	from anthropogenic activities such as decomposition of organic waste at landfills	from anthropogenic activities such as management of manure from livestock
C	from natural processes such as soil respiration	from natural processes, such as cow digestion
D	shorter atmospheric lifetime	longer atmospheric lifetime

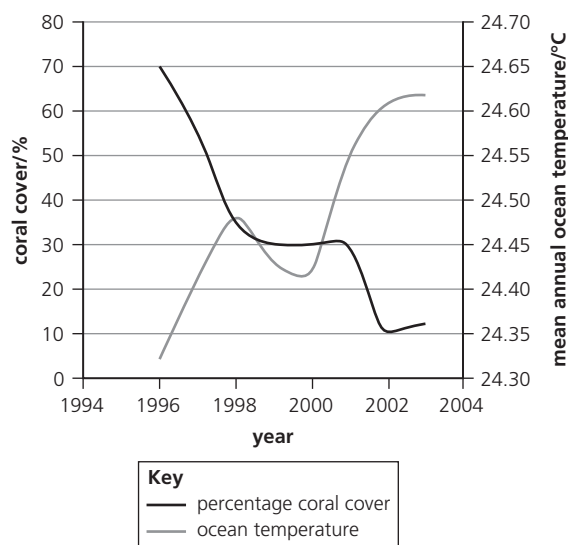
- 3 Which data provides evidence of climate change?
- I Carbon dioxide concentration measured from air bubbles trapped in an ice core from the Antarctic
 - II Changes in glacier formation and melting observed through photographs and maps
 - III Maximum temperatures recorded during summer each year
 - IV Analysis of pollen from plants preserved in different layers of lakebed sediments
- A I only
 - B I and II
 - C I, II and III
 - D I, II and IV

(Questions 4–6 HL only)

- 4 Which of the following are examples of phenological research?
- I The timing of flowering events
 - II Bud set in deciduous trees
 - III Bird migration and nesting
- A I only
 - B I and II
 - C I, II and III
 - D III only
- 5 Which of the following can lead to disruption in the synchrony of phenological events?
- A Increased rainfall
 - B Negative feedback mechanisms
 - C Higher temperatures earlier in the year
 - D Lower temperatures later in the year
- 6 Which of the following is an example of evolution as a consequence of climate change?
- A Increases to the number of insect life cycles within a year
 - B Adaptive radiation in Galápagos finches
 - C Increase in dark brown tawny owls in populations usually dominated by pale grey owls
 - D Increase in melanic form of the peppered moth

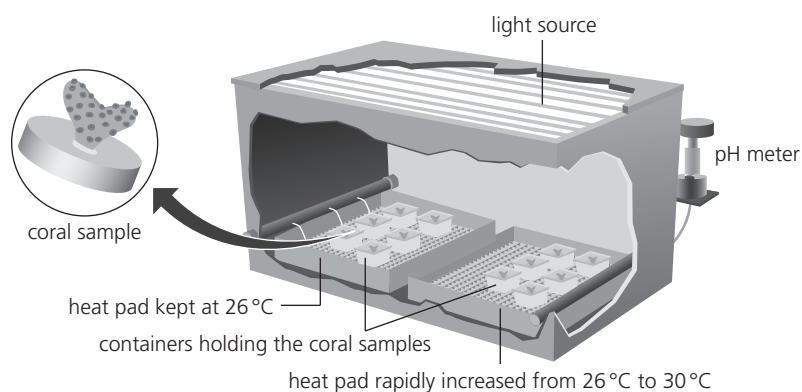
Paper 2

- 1 Coral reefs are among the most spectacular ecosystems on Earth. They support a rich diversity of life and provide economic benefits to the people who use them. In Papua New Guinea in the Pacific Ocean north of Australia the following data were collected. Coral cover is the percentage of the reef surface covered by live hard coral.

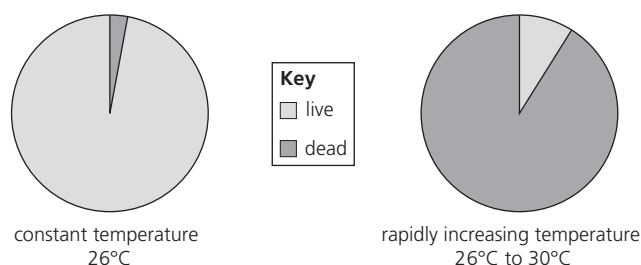


- a Calculate the difference in coral cover in 1996 and 2002. No working required. [1]
- b Describe the evidence that the ocean temperature has an effect on coral cover. [2]
- c Suggest causes for the changes in ocean temperature. [2]

In order to test the effect of temperature, live samples of a species of coral, *Pocillopora damicornis*, were placed in an experimental chamber at a constant pH, water depth and low light. All the coral samples were started at 26°C and half of them were rapidly increased to 30°C.



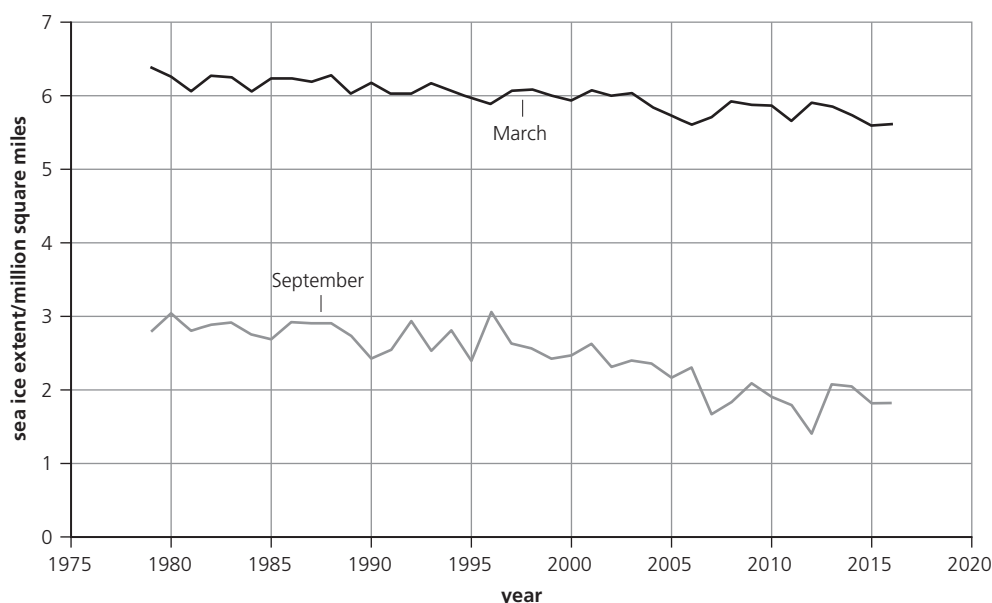
The pie charts show the percentage of live and dead tissues at the end of the experiment.



- d Identify **one** advantage of conducting this experiment in the laboratory rather than in the ocean. [1]
- e Comment on whether the experimental data supports the observed data from the ocean. [1]

Higher Level Paper 2, Time Zone 0, November 16, Q1a–e

- 2 The figure shows Arctic sea ice extent for the months of September and March of each year from 1979 through to 2016. September and March are when the minimum and maximum extents typically occur each year.



- a State which year has the lowest September sea ice extent recorded. [1]
- b State the overall trend in sea ice extent for both September and March. [1]
- c Suggest reasons for the reduction in the Arctic ice sheets from 1979 to 2009. [2]
- 3 Explain how carbon sequestration can be used to mitigate climate change. [7]
- 4 Describe how climate change can lead to habitat loss and the implications of this for biodiversity. [7]
- 5 Outline the role of positive feedback cycles in global warming. [6]
- 6 a Explain the effects of climate change as atmospheric carbon dioxide concentration increases. [3]
- b Explain **two** ways in which climate change damages coral reefs. [2]
- 7 The levels of atmospheric carbon dioxide have been increasing during the past years. Outline reasons for this increase. [4]
- 8 The loss of species from ecosystems as a result of anthropogenic (man-made) climate change is likely to affect food webs.
- a Outline how climate change can lead to the loss of species. [3]
- b Suggest **two** reasons why it might be difficult to establish how the removal of one species from a food web might affect others. [4]
- 9 Describe the impacts of climate change at each level of biological organization. [7]
- (Questions 10–12 HL only)
- 10 Discuss how phenological events can be used to indicate climate change. [5]
- 11 Outline, using an example, how evolution can occur as a consequence of climate change. [5]
- 12 Describe how climate change can affect the life cycle of insects and the impact of this on ecosystems. [5]

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